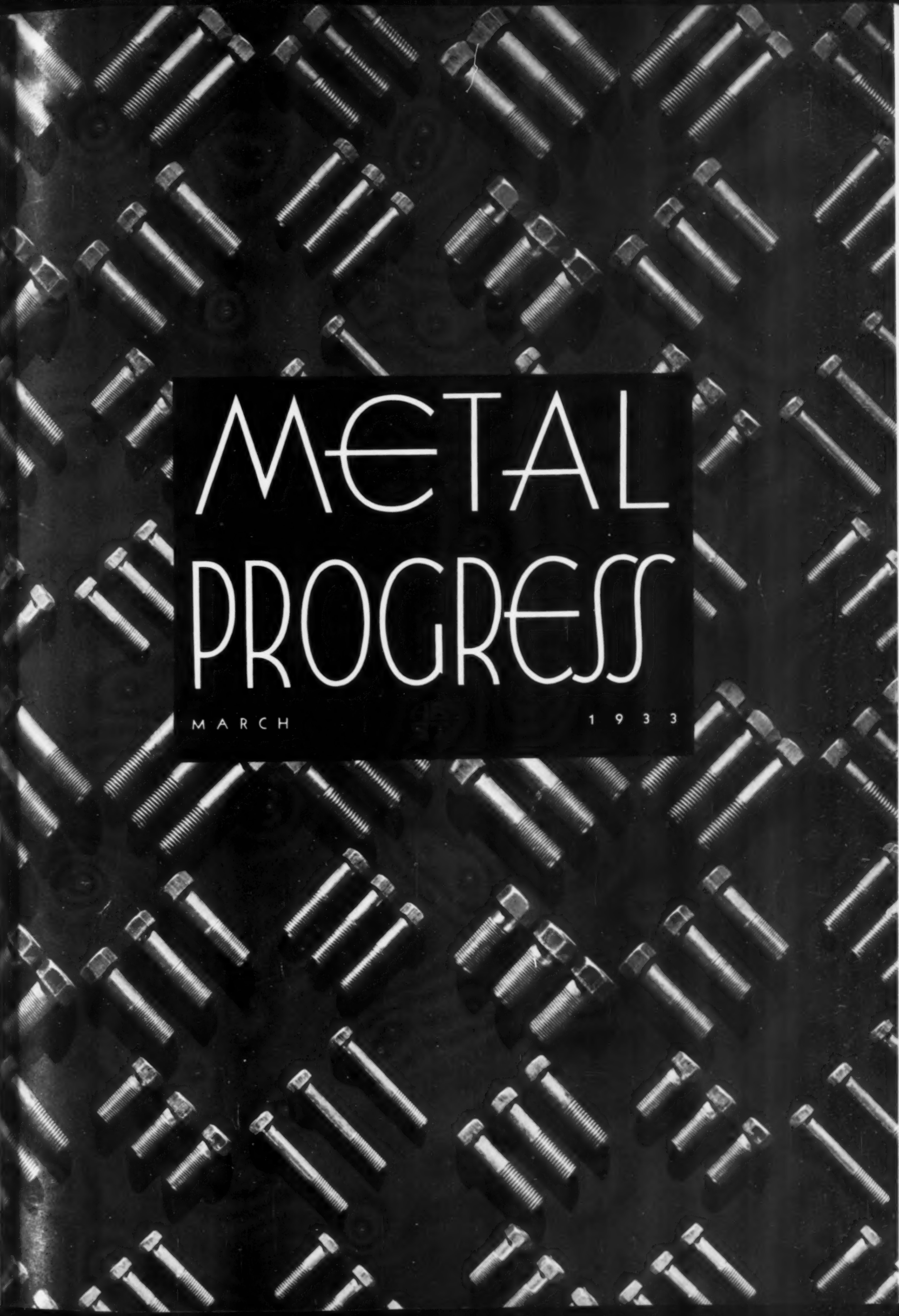
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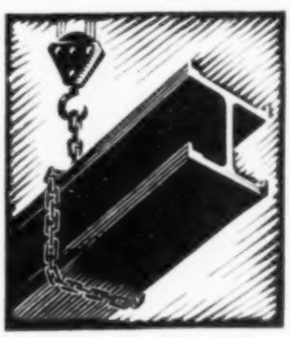

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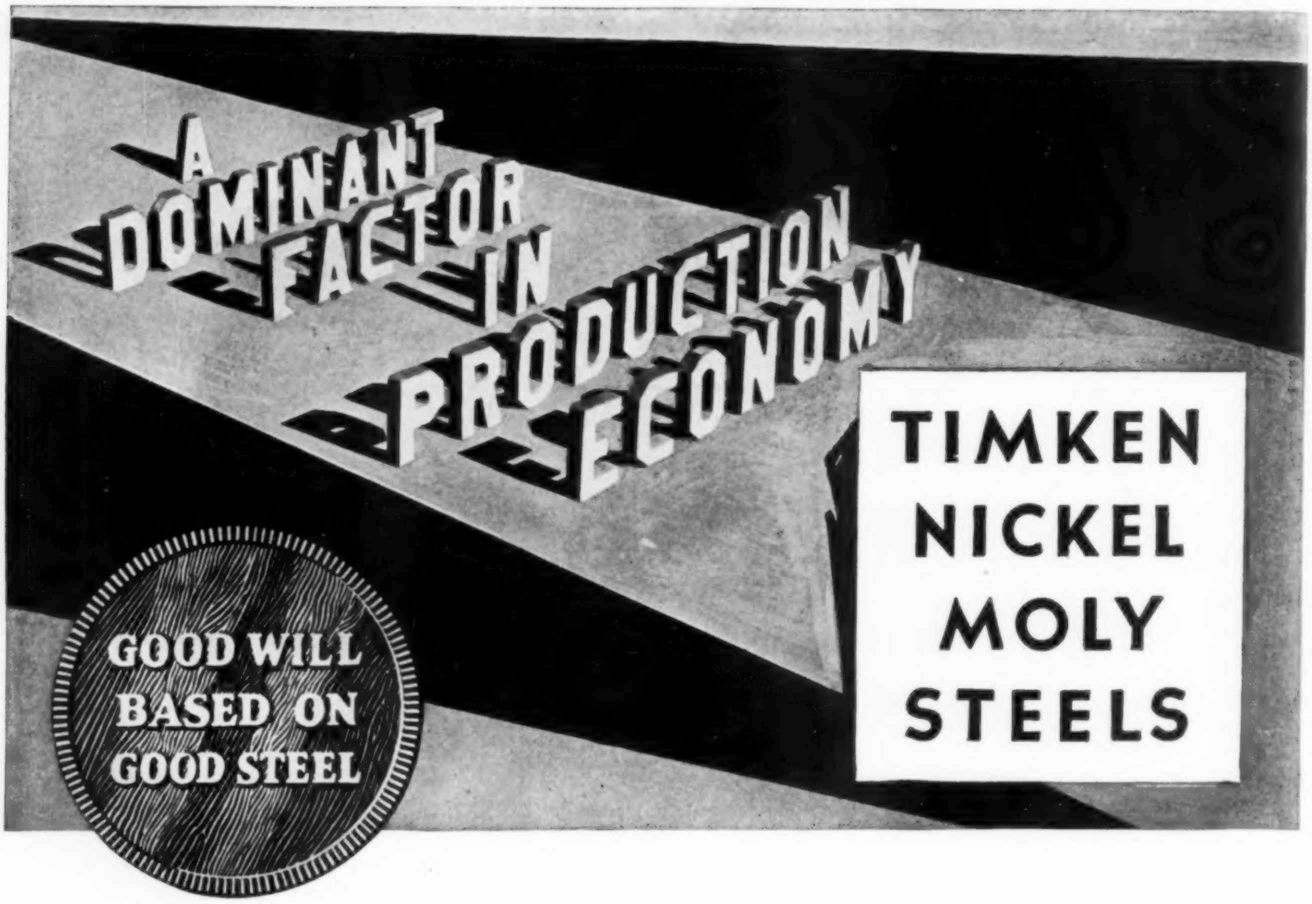
Ernest E. Thum, Editor



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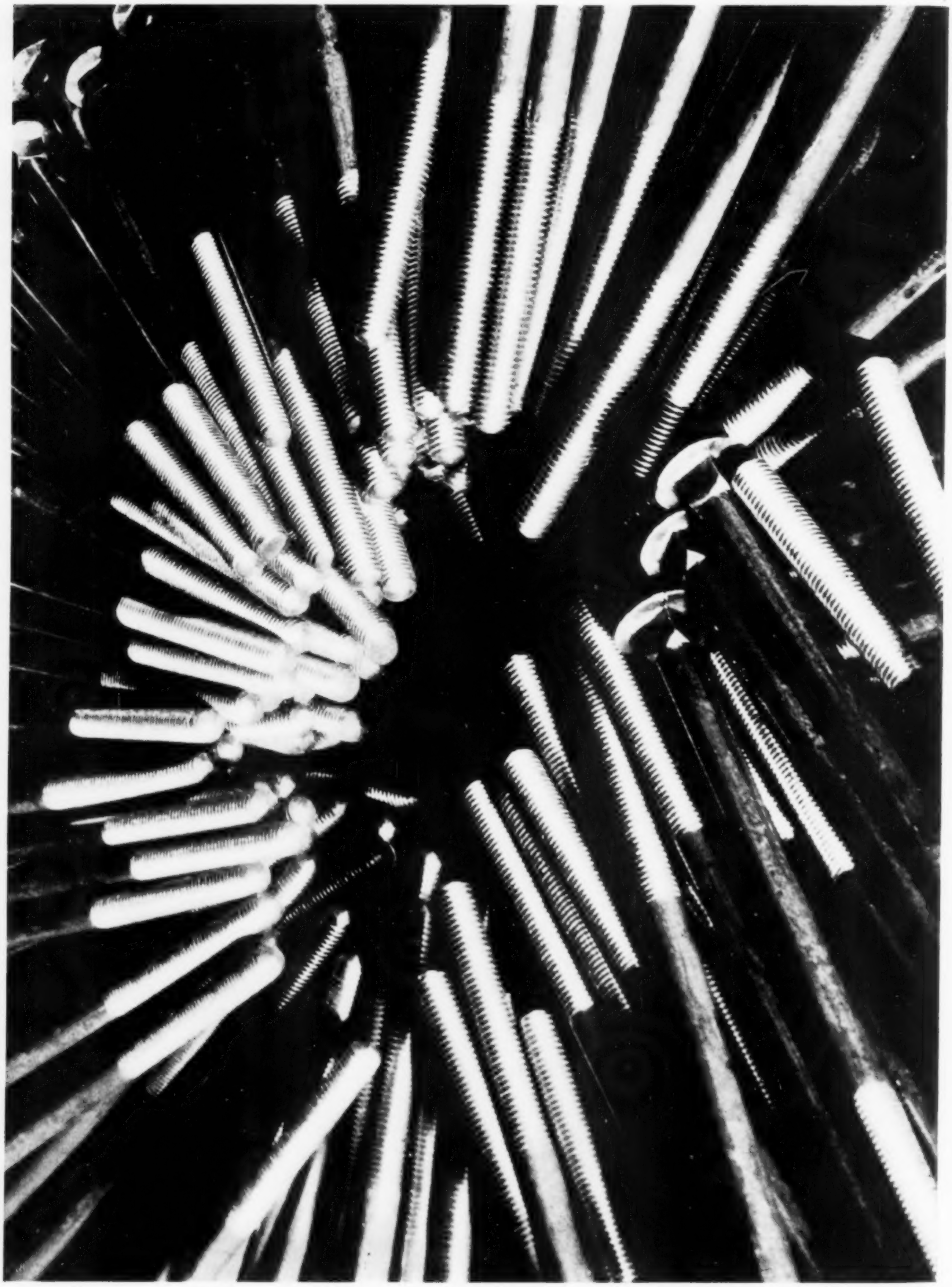


Photo by Margaret Bourke-White *Courtesy Russell, Burdsall & Ward Bolt & Nut Co.*

Bolts, Bolts, Bolts

MATERIALS FOR COLD HEADING

structure more important than composition

By H. B. Pulsifer
Metallurgist
Ferry Cap & Set Screw Co.
Cleveland

THREE chief methods of manufacture are used to supply the needs of our great bolt industry: (1) Screw machine processing, (2) hot upsetting, and (3) cold upsetting. Each has its advantages and deficiencies.

Screw machine manufacture wastes a large fraction of the stock, but easily maintains a perfect axial symmetry if the product is not heat treated. Hot headers easily upset large sizes, but do not give the bright and planished surfaces of the other methods. Cold headers conserve material, but demand stock that is superior in soundness and plasticity.

The methods are not very sharply segregated in the bolt industry, for many factors influence the type of manufacture. There are certain fields where each method is supreme, but other large fields where two or even all three methods compete to supply the industrial requirements.

Present established capacity of the cold heading branch of the industry is probably capable of producing some five billion pieces annually, which would require around 300,000 tons of material in wire form. Wire sizes range from 0.160 in. to ¾ in. diameter, as a rule.

PROPERTIES OF TYPICAL COLD-HEADING MATERIAL
[Pieces Straightened from Wire Coils]

Material	Relative Cost	Condition	Brinell Hardness	Tensile Properties					
				Yield Point	Tensile Strength	Elongation		Reduction of Area	Fracture Load *
						2 in.	10 in.		
0.10% C. Steel	1	Bright Drawn	126	53,000	70,000	18%	5%	62%	120,000
0.38% C. Steel	1.2	Bright Drawn	160	42,000	76,000	38	18	60	145,000
S.A.E. 3115	2.1	Bright Drawn	170	75,000	88,000	16	5	64	150,000
S.A.E. 3135	2.4	Bright Drawn	180	74,000	90,000	23	7	64	165,000
S.A.E. 2330	2.8	Annealed	150	50,000	83,000	36	20	62	162,000
Brass	6	Annealed	70	20,000	48,000	65	52	60	95,000
Everdur	7	Bright Drawn	179	57,000	100,000	16	6	63	180,000
Duronze	9	Bright Drawn	150	44,000	100,000	11	3	65	175,000
Monel	21	Annealed	116	27,000	75,000	62	42	74	185,000

* Load required to break, divided by area of necked-in test piece.

0.390-In. Annealed Brass Wire at 500 Diameters

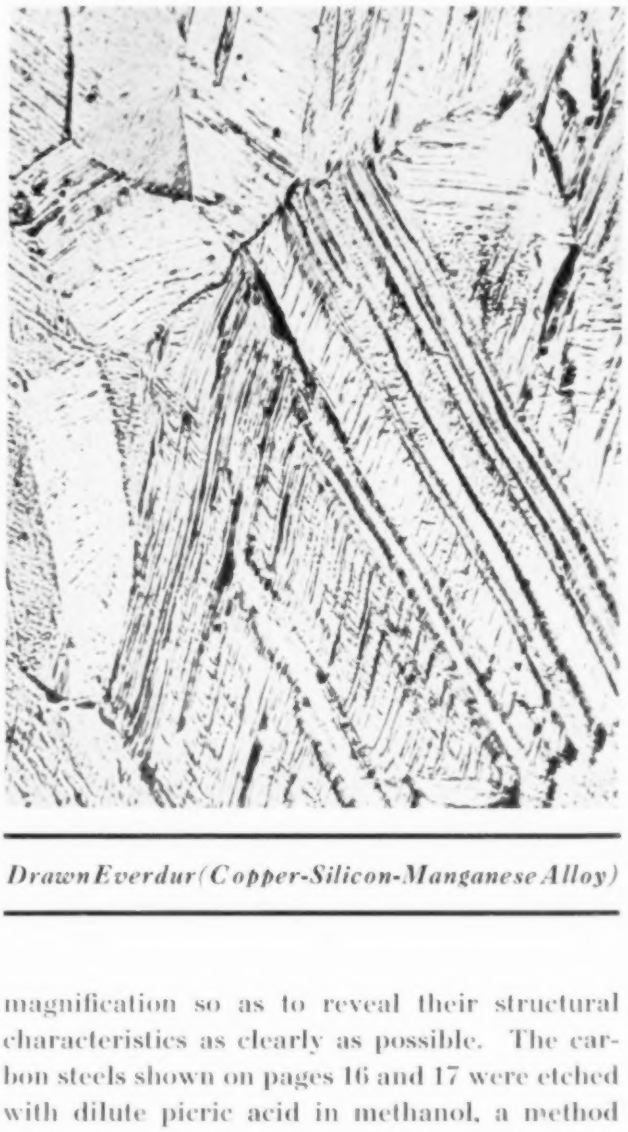
It is the character of this heading material that is now to be reviewed briefly.

A large number of pure metals and alloys can doubtless be easily cold headed, but the requirements of high strength and low cost limit the commercial materials to the alpha solid solutions of iron, copper, and nickel. Furthermore, only a rather limited number of even such alloys enjoy sufficient favor to be stocked, or to be available commercially.

Structure Most Important

From a fabricator's viewpoint, the chemical analysis may vary within wide limits provided the plastic properties of the wire for heading are maintained and the finished articles can meet the requirements of consumers. It is, of course, convenient and practical to adhere to the customary specifications for any given alloy, but in a certain sense the microscopic structure, rather than the chemical composition, determines the heading properties.

The photomicrographs that are given may be taken as typical of the nine materials listed in the table in their normal condition for cold heading. Smoothed and etched longitudinal sections of wire ½ in. diameter, more or less, have been photographed at 500 diameters



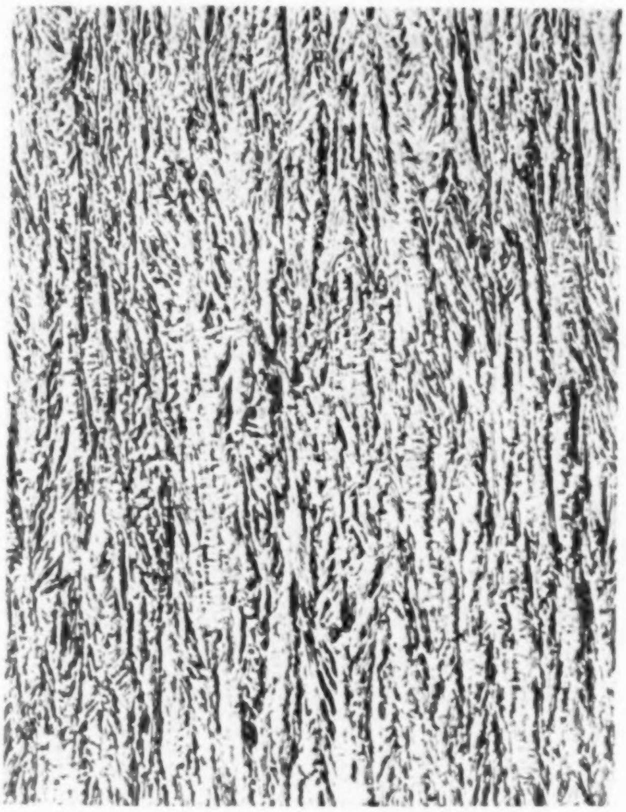
Drawn Everdur (Copper-Silicon-Manganese Alloy)

magnification so as to reveal their structural characteristics as clearly as possible. The carbon steels shown on pages 16 and 17 were etched with dilute picric acid in methanol, a method which is able to bring out the ferrite grain boundaries and the structure of the pearlite simultaneously in an unusually striking manner. Brass and Monel representative of good cold heading material are shown in their annealed condition; the wires were etched with concentrated HNO_3 plus CrO_3. Everdur and Duronze were etched with concentrated nitric acid in acetone.

The first five materials listed in the table, page 13, are steels. Structurally, as seen in the micros on pages 16 and 17, they are alpha ferrite

and pearlite, ranging from large grains of ferrite with isolated patches of pearlite in the low carbon steel S.A.E. 1010 to a structure in S.A.E. 3135 where the relative volume of the two phases is reversed. The pearlite of the fifth material, S.A.E. 2330, merges into spheroidized cementite.

The cementite in pearlite does not appear to detract from heading quality provided the material has a low enough Brinell hardness and is sufficiently plastic, a matter which is related to the figures under "reduction of area" in the table. Even further, the cementite in a fully spheroidized material of these lower carbon ranges does not appear to interfere with heading.



Drawn Duronze (Copper-Tin-Silicon Bronze)

American ingot iron heads easily but has less strength than the low carbon steels.

The steels for cold heading may thus range from wholly ferritic to wholly pearlitic, or even spheroidized cementite in alpha ferrite. Materials containing slag, like wrought iron, or sulphides or selenides, like material for screw machine cutting, are distinctly unsuitable for cold headed products. They are subject to bursts at the bulge of the upset.

The four non-ferrous alloys listed are clean alpha solid solutions of copper or nickel. The brass will naturally contain as much zinc as is convenient without forming any or much beta component. Monel has 28% copper in 68% nickel. Everdur is at the other extreme; 96% copper hardened with 3% silicon and 1% manganese. Duronze is essentially 2% tin and 1% silicon dissolved in copper. A brass that is leaded or contains coarse particles of beta constituent will shear obliquely in the heading operation.

Physical Properties

The table at the head of the article has been compiled to give the relative costs of the above typical raw materials as well as suitable tensile properties and hardness in the heading wire. The materials may be either bright drawn or

Annealed Monel Metal Wire, Etched With Concentrated Nitric Acid and Chromium Trioxide

annealed after drawing, but, if cold drawn, the reduction since the last anneal should not exhaust all of the plasticity. Duronze seems to be able to withstand the greatest reduction without losing plasticity and Everdur comes next in this respect; if the brass or Monel metal rods are much stiffened by wire drawing they tend to shear obliquely on cold heading.

Figures for yield point and tensile strength of the raw material, as given in the table, will be increased from twenty to a hundred per cent in the finished products by rolling the threads or by heat treatments. A rough measure of this eventual strength may be had from the last column in the table, marked "Fracture Load." (Incidentally, the figures for the yield point will be raised relatively more than those for the tensile strength; elongation and reduction of area will be sharply decreased in the final products, for these figures are near their maxima in the heading wire.)

The ordinary low carbon steel listed in the table and shown in the photomicrograph is typical of the materials that make suitable bolt and nut products without heat treatments; this can be used for surface hardened parts. Sometimes the average size of the ferrite grain is considerably larger. Plain steel with 0.38% carbon is typical of those simple steels containing enough carbon to be greatly improved by heat treatment. S.A.E. 3115 represents a series of low alloy steels which make superior surface hardened products. S.A.E. 3135 is shown in the normalized condition, that is, largely pearlitic. A print is also given of S.A.E. 2330 in the partly spheroidized condition. The last two materials make parts that have high strength and toughness in the heat treated condition.

Steels for cold heading, in either the simple carbon or the alloy steels, may have up to 0.65% of carbon and the usual alloying amounts of chromium, nickel, manganese, molybdenum, vanadium, or silicon without interfering too much with the manufacturing routine, provided that alpha ferrite is preserved in the microstructure and the material is not too hard for the dies. Thus the 14 to 18% chrome-ferrites ("stainless irons") are easily headed, but the austenitic 18-chrome, 8-nickel is not so easily headed without oblique shearing.

Wire Surface and Coating

Serious defects in the wire may come from the ingot, the rolling mill, or the wire drawing bench.

Pipe residues and slag inclusions are prone to cause cracking in products that have to be heat treated. Seams from rolled-in fins or from deep scratches, caused by either rolling mill guides or die obstructions, are responsible for "bursts" at the heading operation. Excessive hardness in the finished wire causes oblique shearing on upsetting.

It will appear plausible to assume that the softer the wire the less will inherent defects make their presence known on the finished bolt. On the other hand, the harder the wire the sounder it must be to withstand upsetting successfully. However, a certain stiffness is desired in soft wire so that it will properly fill the recesses of the die and not deform during ejection. A Brinell hardness of from 116 to 196 covers about as wide a range as conforms to economical practice.

The surface of the wire is very important. The bolt manufacturer finds an unsuitable surface, or a defective coating, as serious as any internal defect in the wire. The best wire should be smooth, round, and free from pits and scratches. It should be as little decarburized as possible. Bare, bright drawn wire is prone to seize in the heading dies, so the wire must be coated or surfaced to hold a lubricant.

A variety of coatings have been used on steel wire in recent years. There have been grease coatings, soap coatings, and the rust and lime mixtures known to wire drawers as sull-coat. The latest to appear are "lacquers" or glossy coatings that contain an organic compound.

Solid lubricants unquestionably persist during cold heading better than oils or greases — but only when applied to, or drawn into, a pickled or matte surface. A coating made by dipping pickled wire in a lime wash and then baking is an old and reliable lubricant. High chromium steels of the stainless variety, as well as the 18-8 chromium-nickel steel, appear to need copper plating, in addition to the usual lubricants at the header.

TESTS ON THREADED SECTIONS

show exact strengthening effect of threads

By E. M. Slaughter
National Acme Co.
Cleveland

FOR many years, both the users and manufacturers of bolts, machine screws, and other parts having threaded sections have been confronted with the problem of determining true tensile strength in the threaded section. Many different methods of calculation and formulas have been suggested, and as many different results obtained, with no general agreement. Yet it seemed that a simple method for calculation is very desirable, and consequently a series of tensile tests was made at National Acme Co. to get the necessary evidence to arrive at proper conclusions and results.

Of the several methods now in common use for estimating tensile strength, one calculates the net area from the root diameter as taken from the National Screw Thread Commission table, the second uses a mean area calculated from the average of the root and the pitch diameters, and the third uses the pitch area, calculated from the pitch diameter, also taken from the table.

The present test procedure was to pull some cap screws in an appropriate fixture, noting the load at which the screw broke, and then figure this back to ultimate stress in pounds per square inch, using for area each of the three diameters just noted. The relative correctness was then determined by comparing these three calculated results to the true tensile strength of the bar, as determined by pulling machined test pieces of identical composition and treatment.

Untreated Carbon Steel

In the first series of tests, which were conducted on plain carbon steel of approximately S.A.E. 1035 analysis, each set of screws was made from a single bar of the material approximately 3 ft. in length. For example, all ¼-in. screws, both coarse and fine thread, were manufactured from the same bar of steel. This, of course, should insure identical chemical composition. In addition, six tension test pieces were machined from the same bar, by turning down the body to a diameter just below the root of the thread.

Further, in order to have minimum varia-

tion due to any discrepancies in the cold drawing of the material, all pieces were given a low temperature anneal of 1150° F. Several screws were made and tested on each size of material, both in the coarse and fine thread series. In each case an average of results obtained was listed in the table herewith.

As noted, the first series was made of plain carbon steel having about 0.35% C. Variations in strength of the original bars in the different sizes (shown in the last column) are due to minor variations in chemical composition, history, and quality of the individual bars used. Test results on pieces made from each showed very good agreement among themselves.

In a second series of tests, bolts were made of heat treated S.A.E. 2330, 3130, and 3135 steels. All of these steels are in common use at the present time for the manufacture of studs, bolts, and similar parts which have threaded sections. All tests shown in the second section of the table were processed under ideal conditions, produced with automatic control in the heating, quenching, and tempering operations. Every effort was made to insure uniform conditions and structure in each part. Success in this respect was evidenced by the uniform hardness and tensile strengths developed by the individual test pieces. Rockwell hardness, piece to piece, never varied more than one point.

It is apparent, from inspection of the table, that the strength computed on the area at the root of the thread gives a fictitiously high value, and if the strength is computed on the pitch area it gives a fictitiously low value. (Naturally these discrepancies are less for the fine threads — and the size of the bolt also has an influence.)

If the discrepancies are figured as a percentage of the actual strength of the original bar, it will be seen that the value figured on the root diameter is anywhere from 5 to 16% too large, whereas the value figured on the pitch diameter is anywhere from 3 to 16% too small. Values figured on the mean diameter are generally slightly too small (the deficiency goes up to 3.8%), whereas five of the 22 values are slightly too large.

It is therefore obvious that the mean diameter is closer to the actual diameter of an equivalent bar in tension than either of the other two diameters considered.

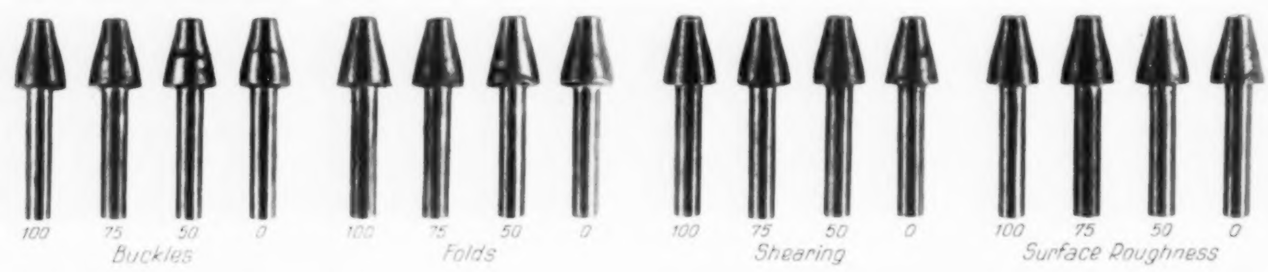
A further effort was made to determine the actual diameter or area in tension of a smooth bar which is equivalent in strength to a given threaded piece. One of four series of such tests will be described in detail:

A 9/16-in. bar of S.A.E. 3130 steel was cut into ten pieces and threaded with a standard fine thread on one end. Two of these were turned above the threaded end to the mean diameter, 0.508 in., of a 9/16-in. standard fine thread. Two were turned to the root diameter, 0.490 in. Two were turned to 0.500 and two to 0.510. All these were then quenched from 1525° F. in oil and drawn at 950° F.

Tested in tension, the first and fourth pair broke in the thread at loads of 28,640, 28,700, 28,770, and 28,840 lb. respectively, or an average of 28,740 lb. to break the threaded section. The ones turned to 0.490 and 0.500 in. broke in the

TENSION TESTS ON CAP SCREWS; FIGURED ON THREE AREAS

Size	Steel	Rockwell Hardness	Coarse Thread			Fine Thread			Original Bar
			Root	Mean	Pitch	Root	Mean	Pitch	
1/4 in.	S.A.E. 1035		82,040	69,620	59,650	78,990	70,590	63,790	70,800
5/16 in.	Do		87,540	76,650	66,200	82,150	74,500	67,450	76,720
3/8 in.	Do		89,650	78,640	69,480	87,810	81,090	74,690	79,110
7/16 in.	Do		97,820	86,050	76,170	93,270	85,810	79,140	88,820
1/2 in.	Do		101,100	89,580	79,890	98,130	91,310	84,800	89,270
9/16 in.	Do		87,050	77,630	69,530	84,920	79,010	73,710	80,340
5/8 in.	Do		90,880	81,340	72,930	88,010	82,480	77,540	82,820
Heat Treated Alloy Steel Screws and Test Pieces									
3/8 in.	S.A.E. 2330	C-28	160,800	141,100	124,700	154,770	142,900	131,700	146,320
1/2 in.	S.A.E. 2330	C-29	156,130	138,400	123,430	160,970	149,800	139,530	143,730
3/8 in.	S.A.E. 3135	C-32	169,060	148,300	131,060	161,000	148,660	137,000	151,080
9/16 in.	S.A.E. 3135	C-34	187,860	167,500	150,100	175,680	163,500	152,500	161,800



reduced section; the average tensile strength of the material figured to 144,300 lb. per sq.in. From these data it is easily calculated that if the unthreaded section be reduced to 0.504 in. diameter it would have a strength equal to the threaded ends.

Three other series of tests on coarse and fine threads of other sizes gave similar results — namely, that a bar reduced to the mean diameter will break in the threads, and that test pieces whose central portion was further reduced a few thousandths to a diameter where its strength was theoretically equal to the strength of the threaded ends, would break either in the threads or in the center.

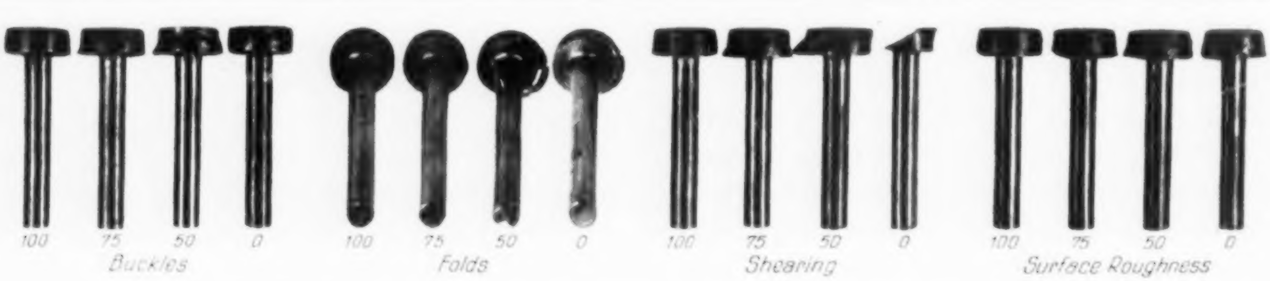
Strengthening Effect of Threads

We know that there is an increase in the load required to break the threaded section, as compared with the section reduced to the *root* diameter. This is due to the so-called strengthening effect of the thread; in our opinion this is caused both by the increased amount of metal in the thread above its root, and the thread form itself.

It has been suggested that the strengthening effect of the thread be included as a factor to be added to determinations based on root diameter. It is our opinion that such an assumption cannot be accepted, and further, that the strengthening effect of the thread increases the tensile strength of a threaded part equivalent to a diameter that is between the root and pitch diameters. Our tests show that the mean diameter is the most accurate method yet proposed, and affords a simple method of calculating strength of threaded sections without the use of complicated formulas.

In conclusion, the following statement may be made:

"The results obtained from calculations based on the root diameter are high, results obtained from calculations based on the pitch diameter are low, as compared with the actual tensile strength of the material determined from a machined section. In most cases, results obtained from a calculation based on the mean diameter are slightly low, yet such results are not too low to be considered as presenting a slight safety factor in the designing and engineering calculations."



At Top and Bottom of This Page Are the Respective Standards Selected by Mr. Crampton, as Described in the Next Article, to Appraise Cold Heading Qualities of Brass Wire, First, as to a Reasonable Amount of Cold Work, and Second, as to its Re-Heading Ability

HEADING PROPERTIES OF BRASS WIRE

as it varies with composition and temper

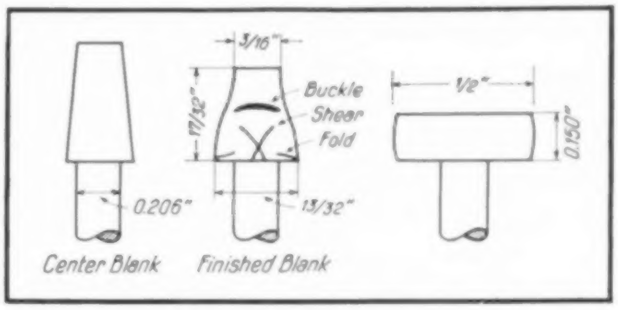
By D. K. Crampton
Director of Research
Chase Brass & Copper Co.
Waterbury, Conn.

THERE is a vast amount of copper alloy wire used annually for rivets, screws, and bolts of various types. The alloy in greatest demand is ordinary high brass containing about 65% of copper, low lead, and the balance zinc. A series of experiments was carried out under the author's direction to find the effect of variations of alloy from this general type, and the influence of initial temper on the ease of heading and the quality of the product.

In all, sixteen different alloys were used. The analyses of these are shown in the table on page 23. It will be noted that the first nine alloys form a series with very low lead and iron contents, and with copper varying from about 64% to 100%. Five others form a series with fairly constant copper between 66% and 67%, but with lead varying from 0.01% to 0.52%. The last three in the table, with the third, form a series with the same constant copper content, low lead, and iron varying from 0.02% to 0.27%.

These alloys were fabricated in the mill in the usual manner of production. They were melted in an Ajax-Wyatt induction furnace; eight rods of each alloy were cast in 2-in. round rods. After suitable scalping of the surface they were cold rolled in grooved rolls, with the proper passes and intermediate anneals, down to about ¾ in. round. They were then drawn cold in the usual manner to 0.410 in. diameter.

At this point six coils of each alloy were taken for actual testing. They were so drawn and annealed as to be finished on 0.206 in. diameter with the tempers shown in the large table. It will be noted that tempers A, B, and C form a series with 6% final area reduction after varying anneals — light, intermediate, and soft. Furthermore, tempers D, B, E, and F (in the order named) form a series with constant previous anneal and varying final reduction, up to 20%.



Center Blank and Finished Blank Used to Appraise Intermediate Heading Ability; Final Shape After Re-Heading Shown at Right

Finished coils of wire were sampled from both ends and various physical tests made. Tensile test results are listed in the table; values are the averages obtained from both ends of the coils. They show a wide range of tensile strengths from about 33,000 to 77,000 lb. per sq. in. (33.0 to 77.0 kips) — a much wider range than is ordinarily encountered in commercial use for cold heading. It should be borne in mind that all anneals were made on full sized coils and normal loads in mill furnaces. Control of properties was not, therefore, as close as could be obtained in laboratory practice.

Wires were tested for heading properties by upsetting heads in an ordinary double blow, closed die header. Initially, about half of each coil was used in making a head as shown in the center of the sketch at the head of this article. This is the usual shape of head made as an intermediate step where the finished rivet or bolt requires too great displacement of metal for a single operation.

The heads so made were rated on four different qualities, the basis for each of these ratings being more or less empirical. The qualities considered were buckles, folds, shearing, and surface roughness.

Buckles are due to the compression and consequent bending of the wire as a column. The wire does not uniformly compress with resultant increase in diameter, but first tends to bend until restricted by the die, and then fills out. This causes a depression, usually about half way up the head, which runs part way around. It may vary in intensity from a slight roughness to a distinct overlap.

Folds come at or near the bottom of the head and are often nearly, if not all, the way around. They result from the change in shape at this point caused by the second blow. The metal just above the bottom of the head tends to lap over the edge formed by the first die (or center blank).

Shearing is an actual failure of the metal due to overwork. The cracks are typical 45° cracks resulting from compression.

Surface roughness is due to slip within the surface crystals. The larger the crystals the greater is the roughness. This roughness is altered to some extent by contact with the die surface, particularly if the article is of such shape as to get much planishing during the forming and ejection.

In order to assist in making these ratings, a set of standards was first selected for each of these four qualities. Each set consisted of four pieces; a perfect head (with respect to the particular quality) was rated as 100% and the worst 0%. Rivets made from coil were compared to the standards and rated either 0, 25, 50, 75, or 100%. With these empirical standards it was felt that a closer rating was not warranted. The halftones on page 20 show the standards used in rating.

Results of the quality ratings are given in the top portion of the large table opposite. The mean of the four individual quality ratings is also figured to the nearest unit. It should be remembered that these ratings are empirical and too precise results should not be expected. Even so, several interesting effects are quite clearly indicated.

Rating After Moderate Work

1. There is no systematic variation of any quality in any temper over the entire range of copper content. In other words, for this particular cold heading operation any copper content from 64% up is satisfactory.

2. An intermediate anneal on the wire previous to a final 6% reduction in the drawing dies seems slightly better than either a lighter or a softer anneal.

3. Increasing the total draft to 13% has but little effect on the cold heading qualities. A 20% final reduction, however, sharply lowers the buckle rating, but improves the surface rating, the mean quality rating falling off slightly.

4. The wires tested with higher lead contents show an adverse effect in the case of the softest anneal and also for the 13% and 20% final reductions, but relatively little effect on intermediate tempers.

5. The high iron material is decidedly lower in cold heading quality for all tempers.

These results are averaged in an over-all figure shown in a line across the middle of the table. It seemed obvious that a greater displacement of metal would more strongly indicate differences in quality. Accordingly, about 30 specimens from each alloy and temper were

COLD HEADING PROPERTIES OF COPPER AND BRASS WIRES

D.K. Crampton

		Brasses								Copper	Leaded Brasses				High Iron Brass		
Composition:	Copper	64.02	65.48	66.59	67.97	69.87	74.72	79.97	89.91	99.93	67.09	66.80	66.29	66.76	66.49	66.65	67.29
	Lead	0.03	0.01	0.01	0.03	0.02	0.01	0.01	0.01	(0.026	0.11	0.20	0.31	0.52	0.03	0.02	0.02
	Iron	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	%P)	0.02	0.02	0.02	0.02	0.10	0.17	0.27
Physical Properties of 0.206-In. Wire and Ratings After Two Strokes on Closed Die Header																	
Temper A [Light anneal, draw 6%]	Strength (kips)	57.8	57.2	61.1	59.0	56.2	59.9	53.6	45.4	37.3	60.1	56.1	58.1	63.2	64.5	63.8	66.7
	Elongation in 2 in.	26	30	21	28	29	21	22	22	22	27	30	28	24	25	23	22
	Buckles	75	75	75	75	75	50	75	75	100	75	75	75	50	75	75	75
	Folds	75	50	75	50	50	50	50	0	0	75	75	75	75	75	50	50
	Shearing	75	100	100	100	100	100	100	100	100	100	75	75	100	75	100	75
	Roughness	100	75	75	75	75	75	100	100	75	75	75	75	75	100	75	75
	Mean	81	75	81	75	75	69	81	69	69	81	75	75	75	81	75	69
Temper B [Intermediate anneal, draw 6%]	Strength (kips)	55.2	57.2	54.6	58.6	57.6	57.0	53.8	41.7		54.5	54.6	58.3	56.3	59.7	61.5	65.9
	Elongation in 2 in.	31	26	31	27	30	25	19	25		28	30	27	29	27	20	17
	Buckles	75	75	75	75	100	75	75	100		100	75	75	75	75	75	50
	Folds	50	50	50	75	75	75	50	75		75	75	50	50	50	50	0
	Shearing	100	100	100	100	100	100	100	100		100	75	75	50	100	75	75
	Roughness	75	75	75	75	75	75	75	100		75	75	75	75	75	75	75
	Mean	75	75	75	81	88	81	75	94		88	75	69	63	75	69	50
Temper C [Soft anneal, draw 6%]	Strength (kips)	54.3	51.6	52.2	52.2	54.9	53.8	50.4	42.1		52.4	55.2	54.6	58.1	55.3	56.0	52.8
	Elongation in 2 in.	32	34	41	38	35	33	30	23		35	29	33	32	34	36	36
	Buckles	50	50	50	75	75	50	50	50		75	75	75	0	50	0	75
	Folds	50	75	75	75	75	75	75	50		75	75	50	50	50	75	75
	Shearing	100	100	100	100	100	100	100	100		100	75	75	75	100	100	100
	Roughness	75	50	75	50	50	50	75	75		50	50	50	0	50	0	50
	Mean	69	69	75	75	75	69	75	69		75	69	63	31	63	44	75
Temper D [Intermediate anneal, not drawn]	Strength (kips)	48.8	50.4	49.2	51.4	50.3	51.8	47.5	41.4	33.3	49.3	50.2	50.8	50.5	50.1	56.4	59.5
	Elongation in 2 in.	55	55	55	56	57	55	51	50	54	60	56	51	55	52	45	42
	Buckles	75	100	100	75	75	75	75	75	75	75	75	75	75	75	50	50
	Folds	100	100	75	75	75	75	50	0	50	75	75	75	75	75	75	75
	Shearing	100	100	100	100	100	100	100	100	100	100	100	75	75	100	100	75
	Roughness	75	75	50	75	75	100	100	100	75	75	75	75	75	75	50	75
	Mean	88	94	81	81	81	88	81	69	75	81	81	75	75	81	69	69
Temper E [Intermediate anneal, draw 13%]	Strength (kips)	60.0	58.6	59.6	60.6	59.8	61.6	59.0	47.8	39.8	59.4	65.4	60.5	60.2	63.3	62.6	68.4
	Elongation in 2 in.	22	23	21	22	22	21	12	10	12	12	14	20	21	18	13	14
	Buckles	75	75	75	75	75	75	50	75	100	75	75	75	75	50	50	50
	Folds	50	50	75	50	50	75	50	0	50	50	75	50	75	75	50	50
	Shearing	100	100	100	100	100	100	100	100	100	100	100	100	0	100	100	75
	Roughness	75	50	75	75	75	75	75	75	75	75	50	75	75	75	75	75
	Mean	75	69	81	75	75	81	69	63	81	75	75	75	56	75	69	63
Temper F [Intermediate anneal, draw 20%]	Strength (kips)	68.2	67.8	68.4	63.6	64.5	64.7	62.5	52.8		63.2	64.1	65.8	68.8	70.0	64.8	77.3
	Elongation in 2 in.	8	14	7	16	16	23	5	5		5	7	7	5	6	10	8
	Buckles	50	50	0	50	50	0	50	0		75	50	0	0	0	0	0
	Folds	75	75	50	75	100	50	75	50		50	50	75	50	50	50	0
	Shearing	75	75	50	75	100	100	100	100		100	75	75	0	75	75	0
	Roughness	100	100	100	100	100	75	100	100		75	75	75	100	100	100	100
	Mean	75	75	50	75	88	56	81	63		75	63	56	38	56	56	25
Overall average for first heading		77	76	74	77	80	74	77	71	75	79	73	69	56	72	64	58
Ratings After Re-Heading to Flat Top Head, 1/2 In. Diameter 0.150 In. High																	
Temper A	Buckles	0	75	75	75	50	0	0	75	75	75	50	50	50	0	0	50
	Folds	50	50	50	50	50	50	50	100	100	50	50	50	50	50	50	0
	Shearing	75	100	75	100	100	75	50	100	100	75	50	0	75	50	75	50
	Roughness	75	75	50	75	75	75	100	75	100	75	75	75	75	100	75	75
	Mean	50	75	63	75	69	50	50	88	94	69	56	44	63	50	50	44
Temper B	Buckles	75	75	50	75	75	50	100	100		50	0	0	50	50	0	0
	Folds	75	50	50	0	0	75	50	50		50	50	50	0	0	50	50
	Shearing	100	75	50	75	75	100	100	100		75	50	0	0	75	50	50
	Roughness	50	50	50	75	50	50	75	100		50	50	75	50	75	50	75
	Mean	75	63	50	56	50	69	81	88		56	38	31	25	50	38	44
Temper C	Buckles	50	0	0	0	0	0	50	75		50	50	50	0	0	0	0
	Folds	50	50	75	0	0	50	50	75		0	50	0	50	75	50	50
	Shearing	50	50	50	50	50	50	75	100		50	0	0	0	75	50	75
	Roughness	0	0	0	50	50	50	50	75		0	0	0	0	0	0	50
	Mean	38	25	31	25	25	38	56	81		25	25	13	13	38	25	44
Temper D	Buckles	75	50	50	50	75	50	50	50	75	50	75	75	0	75	50	0
	Folds	50	0	0	0	50	0	0	100	100	0	0	0	75	0	0	0
	Shearing	100	75	50	50	75	75	100	100	100	75	50	0	0	75	75	50
	Roughness	75	50	0	75	50	75	75	100	75	75	50	75	50	75	75	75
	Mean	75	44	25	44	63	50	56	88	88	50	44	38	31	56	50	31
Temper E	Buckles	50	50	50	0	0	50	75	75	100	75	50	0	0	50	0	0
	Folds	50	0	0	50	50	0	75	75	100	0	0	50	0	50	50	0
	Shearing	75	75	75	75	75	75	75	100	100	50	75	0	0	75	75	50
	Roughness	75	50	50	50	75	75	75	100	75	75	50	50	50	50	50	75
	Mean	63	44	44	44	50	50	75	88	94	50	44	25	13	56	44	31
Temper F	Buckles	0	0	0	0	0	0	0	50		50	0	0	0	0	0	0
	Folds	0	50	50	75	50	0	50	75		0	0	0	0	50	50	50
	Shearing	50	50	50	50	75	50	75	100		50	50	0	0	50	50	0
	Roughness	50	75	75	75	75	75	75	100		75	50	75	75	50	50	75
	Mean	25	44	44	50	50	31	50	81		44	25	19	19	38	38	31
Overall average after re-heading		54	49	43	49	51	49	61	85	92	49	39	28	20	48	41	37

re-headed without intermediate annealing. For this operation a flat punch was used and the heads compressed in a single blow from the form already tested to the approximate form shown at the right of the sketch at the head of this article.

Ratings for the same four qualities were made in precisely the same manner as for the first operation, and tabulated in the lower portion of the large table. The standards of comparison for the various qualities are shown in the lower halftone on page 20, and, as in the previous ratings, factors other than the one under immediate consideration were neglected.

A study of the table shows certain fairly well defined effects. Others are less evident. For the present purpose it appears unnecessary to follow in detail the effect of all combinations of alloy, temper, and individual quality. To aid somewhat in drawing general conclusions, the ratings are averaged for all six tempers in the last line in the table. These results are also plotted in the two curves on this page.

Metal For Re-Heading

The following conclusions may be drawn for the *re-headed* material:

1. There is little difference in any quality over the range of copper from 64% to 75% inclusive. A slight improvement is noted at 80% copper and a very decided improvement at 90 to 100% copper. In fact, these latter alloys could probably be worked very much further without serious trouble.

2. There is not much change in average ratings for the high brasses due to increasing the lead content up to 0.10%, but a decided falling off beyond that amount. The shearing rating shows a decided drop above 0.10% lead and falls to 0 (actual failure) at 0.30% lead.

3. Iron above 0.10% has an adverse effect on all qualities except roughness. Retardation of grain growth with high iron lessens surface roughness.

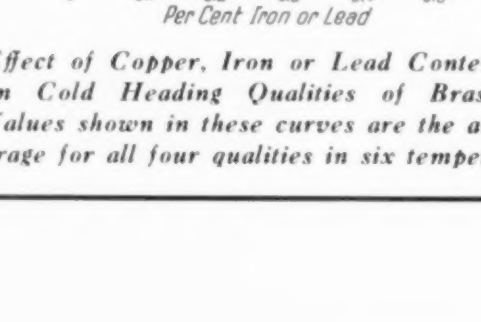
4. Tempers A and B, with final reductions of about 6% after a light or intermediate anneal, are on the whole better than the others. Too high an anneal gives excessive roughness, and too heavy reductions harm the other properties.

5. The harder tempers for all except the high copper alloys give poorer results. The 90% copper alloy shows little variation in cold heading quality with temper.

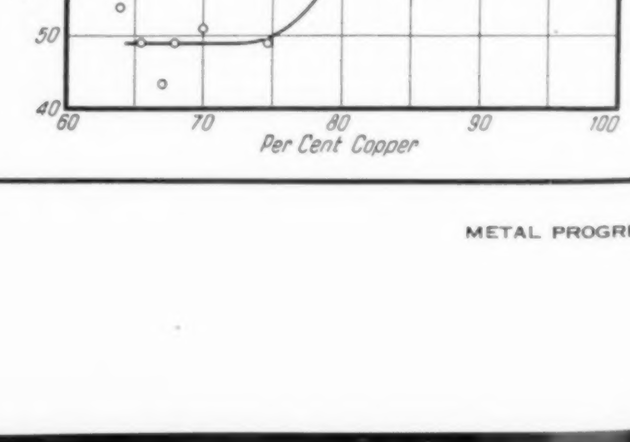
As a result of the above studies (which agree closely with general mill experience) the following recommendations can be made:

(*A*). For the usual run of moderate heading operations a common high brass of about 65% copper, less than 0.10% lead, and less than 0.10% iron, is satisfactory. The most suitable temper is a final reduction of 6 to 10% after a light or intermediate anneal.

(*B*). For extreme metal displacement without annealing between re-headings, a commercial bronze with about 90% copper, less than 0.05% lead, and less than 0.05% iron, gives the best results. The temper is optional, within a fairly wide range, but a final reduction of 6 to 10% after a light anneal is perhaps preferable.



Effect of Copper, Iron or Lead Content on Cold Heading Qualities of Brass. Values shown in these curves are the average for all four qualities in six tempers



RECOMMENDED PRACTICE FOR TESTING

bolts, screws, nuts, studs, and pins

By Subcommittee on Bolts
Recommended Practice Committee
A. S. S. T.

A RECENTLY adopted A.S.S.T. tentative recommended practice (not intended for a specification) notes that inspection may include one or more of the following tests: Chemical analysis; mechanical inspection for dimensions; inspection of finish and appearance; hardness, either Brinell, Rockwell, scleroscope, or file; tensile test (ultimate strength, elastic limit, yield point, elongation, and reduction of area); head test, bend test, shank fracture test, impact test, torsion test, shear test, thread stripping test, macrostructure, microstructure, and inspection of coatings. Notes on several of these tests, in some respects unique to the bolt industry, are quoted below.

Appearance and Finish — These products should be free from harmful defects such as burrs, excessive scale, rough tool marks, dirty threads, rust, and visible defects from the raw material. The application usually determines what may be considered as harmful defects.

Mechanical Inspection — Physical dimensions are determined by suitable rules, gages, micrometers, optical projectors, and special instruments. Thread dimensions and tolerances for the several classes of threaded products are as specified in the report of the National Screw Thread Commission. An essential part of mechanical inspection is the frequent checking of the routine testing instruments against master gages.

Hardness Testing — The Brinell hardness is generally used when the size, shape, and character of the section permit. When possible, the hardness determination on headed sections should be made near the center on the top of the head. The sample pieces may be slightly but smoothly ground when it is necessary to remove scale, decarburization, or surface roughness. Hardness of case hardened products is determined either with the scleroscope or Rockwell hardness tester (C scale).

Tensile Tests — A threaded section may be considered as a cylinder strengthened by one or more spiral ridges which are the threads of the screw. The strengthening effect of the threads is usually greater on the yield point and elastic limit than on the tensile strength and is usually greater for coarse than for fine threads.

An excellent method for writing specifications is to state the minimum load in pounds for the yield point or tensile strength that a given specific part should sustain. This must be appreciably lower than the expected mean loads

because of the distribution of results, as noted at the end.

Bolts that are roll threaded but not heat treated are strengthened more than others with fine or coarse cut threads. The greatest strengthening effect is after a cold reduction of the size of the pieces in the section to be threaded, and then roll threading. Materials that harden rapidly on cold working (such as stainless irons) also have large increases in strength after roll threading. In the extreme case, the strengthening effect of the threads may be 100% of the full cross-section of the piece.

It is recommended that the mean diameter (the mean between the root and pitch diameters) be used as the basis for calculating the area of threaded sections, rather than the area based on root diameter, as is the common practice at the present time. Reasons for such a recommendation are given in Mr. Slaughter's article on page 18. If, when testing a threaded section, it breaks outside of the threads, the area of the section that breaks should be used for the calculation.

The tensile properties of unthreaded portions are calculated on the minimum cross-sectional area.

Tensile tests should always be made of the finished pieces in special self-aligning grips. On threaded sections, tension is applied between the head and a nut screwed onto the threaded end, or the bolt is held in special split grips, threaded internally. Since a straight section turned out of a threaded piece may give a result far from the properties of the piece when pulled as a threaded section, the actual piece should be tested whenever possible.

Elongation — The elongation is usually expressed as the percentage increase in length in 2 in. If the entire elongation is in a shorter length of the threads, divide the total elongation, expressed in fractions of an inch, by 2, to get the percentage elongation in 2 in.

Head Test — To determine if there is proper union between the head and shank, place the bolt sideways on a block of steel with its head just over and against the square edge and hammer the head vigorously.

Bend test on the shank of bolts is an aid in judging the toughness and ductility. It is best made in the tensile machine with a specially designed fixture which contains a mandrel, the rounded end of which has a radius the same as that of the bolt.

Shank fractures show defects such as piped steel, seams, or coarse crystallization. These will probably be visible to the naked eye or through a hand lens.

Impact Test — Bolts, screws, and nuts are usually subjected to tensile impact in service, but, regardless of type, all impact testing should duplicate actual service conditions if possible, especially in the method of supporting specimen, application of stress, and tightness of nuts.

A common qualitative test to determine the core toughness of surface hardened parts is to subject the piece to hammer blows.

Ordinary steels increase rapidly in brittleness as the temperature is lowered to or below freezing. Accordingly, bolts and pins should not be tested at a lower temperature than the one at which they are not expected to show brittleness.

Shear tests are best made in a tensile machine using a special block where close-fitting holes cut into a block and plunger of hardened steel hold the specimen rigidly in alignment.

Thread Stripping Test — The strip test for threads is applied to threaded sections, including nuts, and when possible it should be made in tension on assembled units.

Macrostructure and microstructure should be interpreted by experienced and trained technicians.

Inspection of Coatings — A protective coating may or may not be decorative. A decorative coating, however, must always be protective, because any coating which is not sufficiently protective soon loses its decorative quality.

The decorative quality of coatings is usually determined by visual examination.

The protective quality of a coating may be tested in several ways:

(1) The *outdoor* exposure test, while quite reliable, usually involves more time than is permissible.

(2) The *salt spray* test, in general use for checking the corrosion resistance of coatings, should be conducted in a closed cabinet in which a solution of sodium chloride, 20% by weight, is atomized continuously at 70° F. so as to give a visible fog *(Cont. on page 58)*

GRADED OR INTERRUPTED HARDENING

avoids cracks and soft centers in high alloys

By Hans Diergarten
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MODERN equipment, such as X-rays, oscillographs, magnetometers, dilatometers, and improved microscopes, has given a new impetus to researches into the process and nature of hardening by quenching — a matter of such great importance to technologists. Much attention is being shown to this matter in Germany, as can be inferred from the large attendance at lectures on the theory and practice of hardening steel given before the last general meetings of Verein Deutscher Eisenhüttenleute and Gesellschaft für Metallkunde (leading associations of German firms in the metal industry).

The work of different investigators has been summarized in *Archiv für das Eisen-Hütten-Wesen*, No. 7, 1932. Dr. Franz Wever's work is of special value to actual practice, and a brief summary of it will now be given.

Dr. Wever and his associates have come to the conclusion that the hardening phenomena cannot be adequately understood by ascribing the results to unstable metallographic forms caught in the steel during rapid cooling. On the contrary, a comprehensive explanation can only be given on a dynamic basis — that is to say, by studying the reaction speeds at fixed temperatures. These transformation - time curves have been already used with good effect in America by Dr. E. C. Bain and described in his Howe lecture before the Mining Engineers a year ago. He studied the rate at which austenite changed into ferrite and carbide, and the dynamics of the same reaction have been investigated with magnetic equipment at the Kaiser Wilhelm Institute at Düsseldorf, Germany.

It would appear that if a nickel-chromium steel (similar to S.A.E. 3340) is cooled fairly rapidly from say 860° C. or 1600° F. to some temperature below the transformation and held

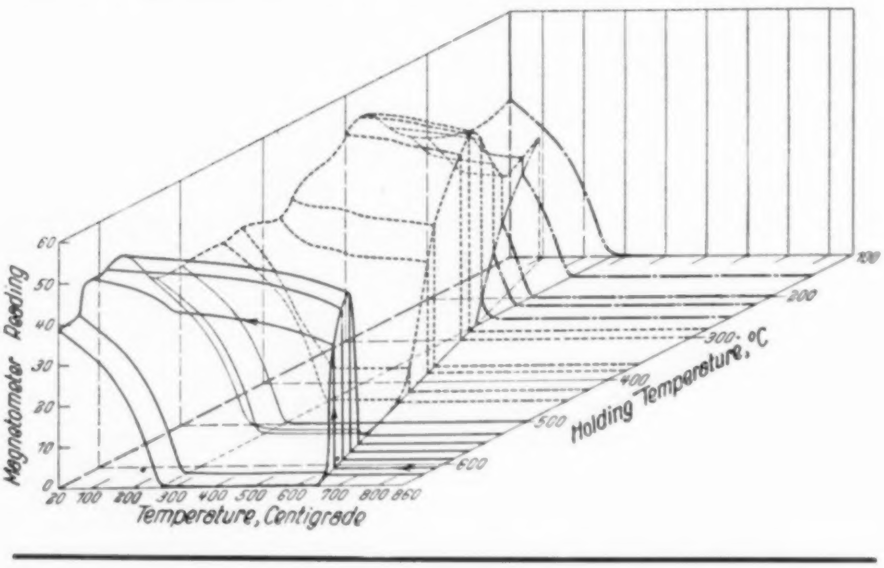
TABLE I - HARDNESS OF HIGH SPEED STEEL

Quench from 1300°C Into	Rockwell C Hardness After Reheating at 580°C					
	Not Reheated	20 Min.	1 Hr.	3 Hr.	10 Hr.	30 Hr.
Lead at 550°C	64.5	64.8	63.4	60.5	58.0	54.0
Lead at 350°C	64.2	64.0	64.0	60.5	56.5	55.0
Oil at 20°C	64.5	65.0	64.5	60.5	59.0	55.0
Still air	64.2	64.0	64.0	61.0	57.8	56.0
Air blast	63.5	64.0	64.0	61.0	59.0	57.0

steady at the lower temperature for some time (2 hr. has been used in many experiments), austenite is produced whose stability is the greater or smaller depending upon the correct choice of holding temperature. Definite structures are formed which correspond to definite heat treatments. Furthermore, microstructures characteristic of quenched steels or quenched and tempered steels can be secured by the above heat treatments, which may be called "graded hardening" or "interrupted hardening" *(gestufte Härtung)*.

To be more precise, suppose the nickel-chromium steel is soaked at 860° C. and quenched in a salt bath at 365° C. (690° F.) and so arranged that the magnetism of the specimen can be measured periodically. Within 17 min. the magnetometer deflection is 13 units; in 25 min. it is 24 units; in 80 min. it has grown to 34 units; and after 2 hr. it is 35 units (thus indicating the presence of about all of the ferromagnetic substance which can be formed from the austenite at that temperature).

A number of such curves were made by Dr. Wever at different temperatures of the quenching medium, and the results are shown in the accompanying three-dimensional diagram in which three definite steps can be distinguished, as well as one range (460° to 530°) where austenite is stable.



A Series of Temperature-Magnetization Curves for a Steel Containing 0.35% C, 0.86% Cr, and 4.04% Ni. Samples were quenched from 860° to the temperature noted at the right and held there for 2 hr., then cooled rapidly. Readings of the magnetometer show transformation of austenite, which is non-magnetic, into magnetic ferrite

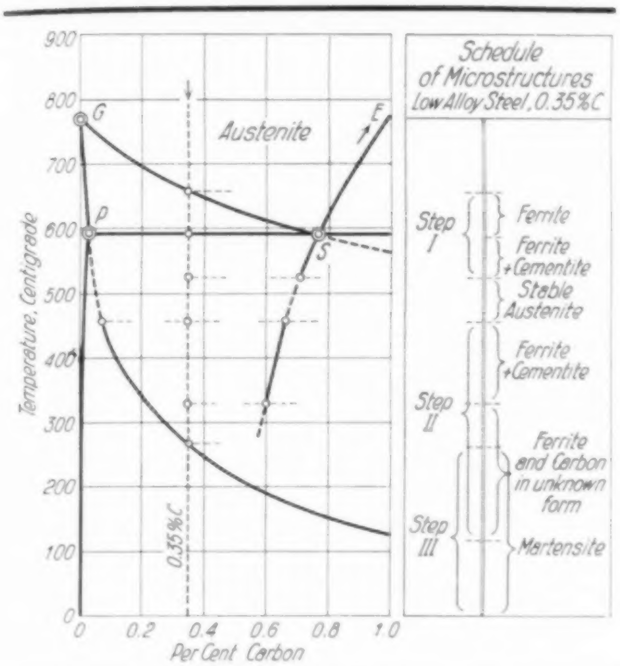
Step I. When the steel is quenched to within the range 660 to 530° C., and held there, a magnetic phase appears; its greatest amount is at about 575° C. (1070° F.).

Step II. Although austenite appears to be stable if quenched to about 500° C. (930° F.), such transformation as will occur in nickel-chromium steels quenched to temperatures between 450 and 280° C. is practically complete after holding for 30 min., even though the amount of magnetic phase appearing at say 425° C. is relatively small. At a holding temperature of 330° C. (625° F.) practically all the austenite is transformed in 2 hr.

Step III. When quenched in mediums cooler than 280° C. a third transformation appears, characterized by a break in direction of the curve at 280° C. which cannot be suppressed nor shifted to a lower temperature even by the most rapid cooling now available.

The second figure, also due to Dr. Wever, correlates the above magnetic studies with microstructure. When the holding temperature is just under the eutectoid horizontal *PS*, ferrite with cementite granules is formed if time enough is given. A little lower in Step I lamellar pearlite will be observed; at the lower edge, troostite will be the end point. This proves the statement made above that the microstructure depends not so much on the cooling speed as upon the time provided at the heat at which the transformation would normally occur.

In the second step, at about 450 to 350° C. (840 to 660° F.) alpha iron and cementite are formed, but some austenite does not transform. This step can likewise be interpreted as a zone



Portion of Iron-Carbon Equilibrium Diagram Showing Relationship to Stepped Decomposition of Austenite When Quenched to Temperatures Below the Critical and Held There for Hours

where pearlite forms at a very slow rate. Theoretically, the austenite should become enriched in carbon, although at such low temperatures no diffusion of carbon can be noticed.

In step III, when steel is cooled promptly to 280° C. (535° F.) martensite begins to form at an extraordinarily rapid rate as compared to the speed of transformation in the first two steps. Nevertheless, when the sample is held for a long time at temperatures near the top of the third step, the tetragonal martensite decomposes into ferrite and highly dispersed carbide.

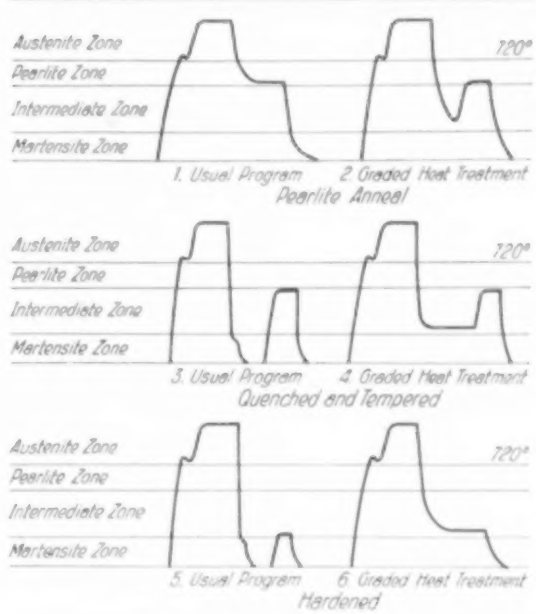
On the above basis Dr. Wever has recommended graded or interrupted heat treatments for steel according to the third group of diagrams.

In graded annealing to pearlite (top sketch) it is proposed to cool rapidly into the intermediate zone and subsequently reheat into the pearlite zone and hold there. This should shift the transformation to a lower temperature than though the steel were cooled just under the A_1 point and held there, and thus give more leeway in heat treatments designed to produce pearlite or spheroidized structures.

Graded quenching and tempering, as indicated in the second pair of curves, should have the advantage that the required tensile properties can be attained without first going through the martensite step, with all its danger of internal stresses, hardening cracks, and volume changes.

In practice it is impossible to insure identical cooling rates, so the influence of speed through the pearlite and intermediate zones to just above the martensite point was investigated. A steel with 1.03% C, 1.21% Cr was quenched in various mediums at 220° C. (430° F.) held there 30 sec., and then completely cooled in oil. Rockwell hardness and bending strength, as well as the deflection, of these test pieces were independent of the cooling rate down to 220° C. Other samples were uniformly quenched to 250° C. in lead-tin baths, held there 60 sec., and then cooled further in different mediums. The values so obtained show that the hardness is quite independent of the cooling rate through the martensitic zone III.

Results similar to those described by Dr. Wever are not unknown to the steel hardener, although he could formerly give no accurate explanation. For instance, the process of graded hardening is applied to most high speed steels. Values secured at the SKF Industries, such as those shown on page 27, are generally known. Despite different cooling rates in the quench, the same hardness is obtained, and the variously



Time-Temperature Programs for Usual Heat Treatments and for Corresponding Graded or Interrupted Heat Treatments

TABLE II - HARDNESS OF Cr-Ni-W STEEL AFTER GRADED HARDENING

Quench from 850°C Into	Fracture	Rockwell C Hardness After Tempering at 175°C in Oil					
		Not Tempered	20 Min.	45 Min.	1½ Hr.	3 Hr.	6 Hr.
Oil at 23°C	A						
Lead at 350°C, 3 min.*	B	63.5	60.5	60.0	59.5	59.0	59.0
Oil at 250°C, 3 min.*	C	63.5	60.0	59.0	59.0	58.5	58.0
Oil at 150°C, 3 min.*		63.5	60.0	59.5	59.0	58.5	57.0
Lead at 350°C, 10 sec.*	D	63.0	60.0	59.0	59.0	59.0	58.0
Oil at 250°C, 10 sec.*	E	63.5	60.0	59.0	58.5	57.7	56.7
Oil at 150°C, 10 sec.*	F	63.5	60.0	60.0	59.0	58.5	57.2

* Subsequent cooling from hot bath was in cold oil

TABLE III - GRADED HARDENING OF 1% C, 1½% Cr BALL BEARING STEEL

Quench from 855°C Into	Fracture	Rockwell C Hardness After Tempering					
		Not Tempered	20 Min.	45 Min.	1½ Hr.	3 Hr.	6 Hr.
		Tempered at 175°C in Oil					
Oil at 25°C	M	66	65	64	63	63	62
Lead at 350°C, 3 min.[o]	N	47	47	47	47	47	47
Lead at 350°C, 10 sec.[o]	P	66	64	63	63	62	62
Oil at 250°C, 3 min.[o]	O	61	59	58	58	58	58
Oil at 250°C, 10 sec.[o]	Q	66	64	64	62	62	61
		Tempered at 150°C in Oil					
Oil at 170°C, 3 min.[o]	R	61			60.5	59	
Oil at 170°C, 3 min.[a]		61			61	58.3	
Oil at 150°C, 3 min.[o]		63			63	61	
Oil at 150°C, 3 min.[a]		64			63	62	
Oil at 170°C, 10 sec.[o]		62			61	59.7	
Oil at 170°C, 10 sec.[a]		39			39	39	
Oil at 150°C, 10 sec.[o]		64			63	61	
Oil at 150°C, 10 sec.[a]		38			39	39	

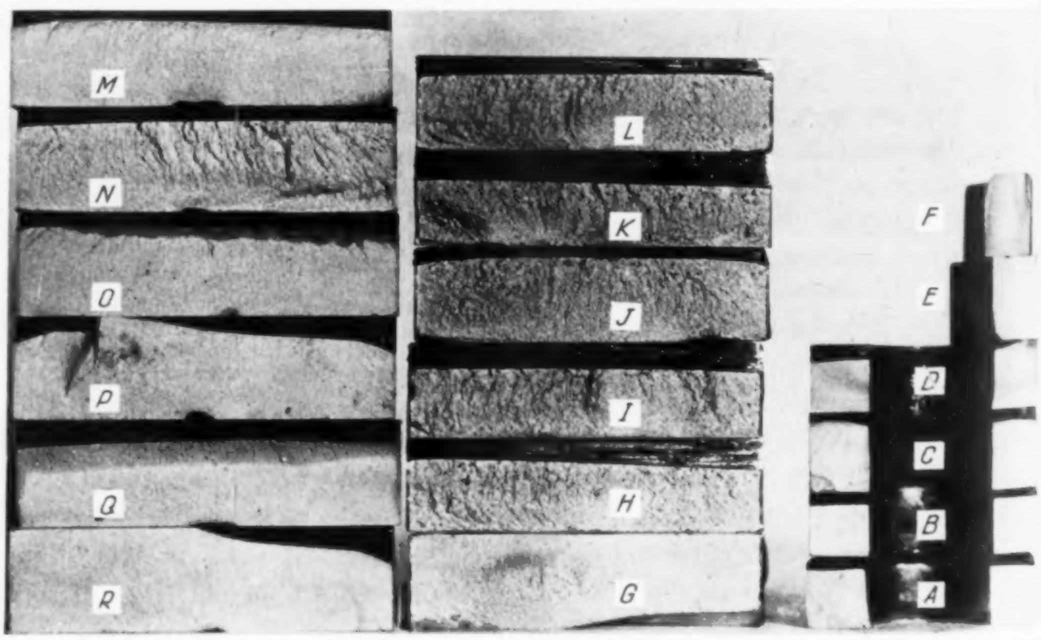
[o] Subsequent cooling in cold oil [a] in air

quenched steel remains in the same condition after similar annealings. Nevertheless, the table shows that when annealed for long times, the high speed steel with the most rapid quench (cold oil or air) shows better hardness. The steel from which the results of Table I were secured contained 0.85% C, 4.5% Cr, 4.5% Co, 18% W, 0.7% Mo, 1.8% V. It was quenched from a salt bath at 1300° C. (2375° F.) in five different ways, and samples of each quench reheated in a lead bath at 580° C. (1075° F.) for the time indicated before testing.

We have also found that a lower alloy chromium-nickel-tungsten steel is suitable for graded hardening. Table II shows that in spite of different cooling rates from the quench the same hardness may be secured. The samples were small rings ⅜ in. thick; fine fractures (shown in the halftone on this page at the right) resulted from all heat treatments. This steel analyzed 0.60% C, 0.38% Mn, 1.15% Cr, 4.0% Ni, 0.9% W, 0.30% Si.

Straight carbon steel does not respond to graded hardening. A series of ½-in. disks was quenched and drawn according to the program shown in Table II, except that water at 23° C. (730° F.) was substituted for cold oil. Only when quenched in cold water was the hardness high (C-64 to C-66) and the fracture good (see the center pile in the halftone). Graded quenchings gave hardnesses between C-45 and C-47.

On the other hand, a normal ball bearing steel with 1.00% C and about 1.50% Cr shows a tendency to respond to graded hardening, as shown in Table III. *(Continued on page 62)*



Fractures of Samples Heat Treated According to Conditions Shown in the Tables. At left is chromium ball bearing steel; at center is plain carbon tool steel; at right is chromium-nickel-tungsten low alloy steel. Full size

. . . E D I T O R I A L . . .

Steel for Fabric

LIKE it or not, competition is a very effective method of shaking out complacency. It may be a wasteful method of determining the best of a group, but given free reign it does it. That goes for materials as well as for men and business organizations.

We are especially interested in the competition of metal with other materials, for when metal is successful all the more opportunities for metallurgists are created. Unfortunately, most of the battles are waged metal against metal, and not metal against wood, cement, brick, plastics, or organic materials. So it is real news when one finds metal replacing fabric:

Even in these days of peace, several million rounds of machine-gun ammunition are used each year for training the infantry, aviation, and navy. In years past the cartridges were slipped through loops in a fabric belt, and the gunner contended as best he might against variations due to manufacture, humidity, temperature, and age. The modern way is to stamp out three-eye links from high carbon strip. They interlock as hinges, so that each cartridge forms a pin of a continuous metal chain; the shells are held firmly enough by one eye so they cannot get out of line, but a second eye is loose enough to give easy flexibility to the chain in all required directions.

As in the manufacture of high grade springs, 100% inspection is the most expensive step in the production line, for five men and a battery of machines can stamp, heat treat, clean, and plate the hinges for 0.30-caliber ammunition at the rate of 200 per min., whereas 15 are required to inspect them.

Technocratic Bunk

TECHNOCRACY makes good conversation. That's about all it is—conversation. For a couple of centuries people have had a notion that more machines and power mean less labor; we've only now begun to lie about it.

It's regrettable that the chief technocrat and his publicity man were so careless with their decimal points. They say "One man in incandescent lamp manufacture is doing today in one hour as much as it took him 9000 hr. to do in 1914." General Electric Co. says it now has 4900 employees making lamps. On the technocratic basis of a 9000-fold increase in productivity it would have taken 14,000,000 men to produce the lamps it actually made in 1914!

The technocrats say, "One hundred men working steadily in modern plants could produce all the bricks the country needs." The engineer-manager of the New York & New Jersey Common Brick Association states that this figure works back to approximately 400,000 brick per man per day, whereas the most highly mechanized plants now seldom exceed 2000 brick per man per day.

From a technocratic pronunciamento: "In pig iron production, one man working one hour can do what it took him 650 hr. to accomplish 50 years ago." *The Iron Age* has divided the actual tonnage made in America by the census figures on employment and finds that the annual production per worker was 1710 tons in 1929 and 74 tons in 1879 — a 23-fold increase rather than 650-fold. (That's bad enough without any exaggeration, perhaps, but there's room for argument even there, for many graduates of the stock pile and cast-house would be glad if the larger figure were correct!)

E D I T O R I A L

Speculation about the meaning of all this mechanization is not even new. We recently looked through a pamphlet written by a "production engineer" of 1913, and his opening data read much like the above. His conclusion as to the meaning of the figures was different, however, for he hailed the advent of the workless week, even though he doubted whether much leisure would bring much happiness.

Going a little further back, you can read a vastly interesting book called "Erewhon," written sixty years ago by the English author Samuel Butler. It is a romance about a country which had banished all machines, even watches and money, before they enslaved men. It's also good literature, which is more than can be said for much of the technocratic and economic bunk that's published now-a-days.

You can push further back into history than that, if you want to, for as Archimedes said when he constructed his first catapult to throw stones against the enemy: "This will put a lot of soldiers on the shelf!"

Magnetic Hardening

IN SEVERAL issues since the beginning of 1932, Metal Progress has allotted space to a discussion of the peculiar hardness fluctuations noted in magnetized metals by E. G. Herbert. Mr. Herbert's past contributions to metallurgical technique warranted ready acceptance of these new discoveries. Nevertheless, other skilled investigators have been unable to find a similar relation between metallurgical hardness and past exposure to high magnetic fields.

With the three letters published in this issue (page 46) the editor will call a moratorium, with these general observations: From a scientific viewpoint one can postulate some intimate relationship between magnetism, elasticity, and atomic cohesion. Unfortunately, too little is known about the essential cause of magnetism to get very far along that line. We can also remember how hopelessly involved became former attempts to explain simultaneously the changes in hardness and magnetism of quenched steel — a matter which has been straightened out only in recent years.

From a practical viewpoint it would appear that if a certain sized test piece must be placed on a magnet of certain dimensions and field strength, and then tested by a certain hardness tester in order to show any changes due to the magnetic treatment, then Mr. Herbert's method must have very limited industrial application at present.

Stainless Iron

THE leading article in last month's issue on "Manufacture of Stainless Iron" by A. L. Feild was a 50% condensation of a chapter for a forthcoming book on the stainless alloys. Some unwarranted inferences and errors therefore crept into the story as printed, which the author had no chance to correct, he being abroad.

Mr. Feild now writes that a casual reader would infer that the conventional principles of manufacture described on the first page under the crosshead "Use of Low Carbon Ferro" represent the methods used by his associates, Rustless Iron Corp. of America, whereas the latter does not employ low carbon ferrochrome. In the accompanying statement that "all low carbon stainless steels and irons are manufactured in America in the basic electric arc furnace" the word *basic* should not appear.

He also wishes to correct the reference to the use of magnesium in the manufacture of high chromium steels containing from 8 to 35% of nickel. His original manuscript had a section describing alloys containing from 59 to 66% of nickel and it was made clear that this use of magnesium is limited to such high nickel-chromium alloys. Steels containing 8 to 35% of nickel contain so much iron that the introduction of magnesium would be violently explosive, and he does not know of any instance where its addition has been proven to be beneficial.

ENGINEERING RESEARCH AT MICHIGAN

accomplishments during eleven years' growth

By A. E. White
Director
Department of Engineering Research
University of Michigan

IN 1921, the Regents of the University of Michigan, recognizing an opportunity for directly serving general scientific and industrial interests, voted to establish the Department of Engineering Research. The purpose of this department was to be a link between the university and industrial and technical organizations; to place the facilities, the libraries, the laboratories, and the trained personnel of the engineering and science departments at the disposal of manufacturing concerns.

Although engineering experiment stations had been in operation in a number of American schools for several years, it was usual for them to receive their major support from state or college grants rather than from industry. In developing the Department of Engineering Research at Ann Arbor, just the reverse policy was followed, since the appropriation by the institution was relatively small.

Starting in 1920 with a grant of $10,000 and a staff of two persons, the department developed rapidly until in 1931-32 it employed a regular staff of about 25 persons on full time, about 45 part-time investigators from the faculties of the various engineering and science schools, and 128 part-time assistants, many of whom were graduate students; 167 research projects were carried on and a total of approximately $250,000 was expended. This figure becomes even more significant when it is considered that business was greatly depressed in that same period.

Some time and effort was necessary to demonstrate to business executives that when a program is properly organized, the university is an ideal place in which to conduct research work. Many executives then felt (and some still do feel) that, although the men on the faculties of our institutions may be men of excellent theoretical background and good teachers, they are insufficiently informed on industrial trends to be of material assistance on practical problems. The growth which this department has experienced and the growth of similar departments in other institutions has done much toward breaking down this feeling.

When viewed from a strictly business perspective, it becomes evident that the university can offer many advantages in conducting industrial research. For example, no single industrial laboratory has the variety or the amount

A Bank of 15 Units Is in Constant Use Studying Creep in Metals at Elevated Temperatures. On the next page is a view of one of the sound testing laboratories set up to study and analyze the noises in automotive transmissions and axles

of research equipment that is found at Ann Arbor.

The libraries of the university are a great aid to research. Aside from the general library, the principal collections useful for industrial research are the chemistry, engineering, physics, and natural science libraries, which together house about 70,000 volumes. These four library branches subscribe for 850 periodicals, including all leading foreign technical publications.

Many Experts Available

Another source of strength with regard to a program of work at the university is what may be spoken of as the "composite mind." No problem is necessarily a problem in any one specific field; it may be attacked from various angles in more than one branch of science. In an institution such as the University of Michigan there are available eminently capable minds in the fields of mathematics, engineering mechanics, civil engineering, mechanical, electrical, chemical, metallurgical, marine, and aeronautical engineering, as well as in chemistry, physics, and other scientific departments.

The use that is made of these departments is well illustrated in an investigation made on turbine shafting a few years ago which might have been attacked solely from a metallurgical standpoint. In place of relying exclusively upon the judgment of one person, however, the presence of internal stresses in the shaft in question was determined by means of X-rays by a physicist; the nature and amount of these stresses were determined by an engineer in the Department of Engineering Mechanics; the composition of the shaft and possible harmful non-homogeneities were determined by a research chemist; the structure and properties of the shaft were investigated by a metallurgist. All of the information thus obtained was correlated and proper recommendations resulted as to the manufacture and heat treatment for subsequent shafts.

Routine testing is discouraged at the Department of Engineering Research, for there are many commercial laboratories in Michigan much better fitted for this type of work than is the university. The training given to the personnel, their education, background, and scientific attitude make them much better fitted for a program of research. In short, the advantages to cooperating industry are the multiplicity of viewpoints, the varied training of the personnel, and the large amount of special equipment available.

Two questions which always arise with regard to research work at a public institution deal with the matter of publicity and the matter of patents. These questions have been very carefully considered and a definite procedure has been developed in both instances.

As for publicity, it is stated definitely in the contract executed by the cooperating business

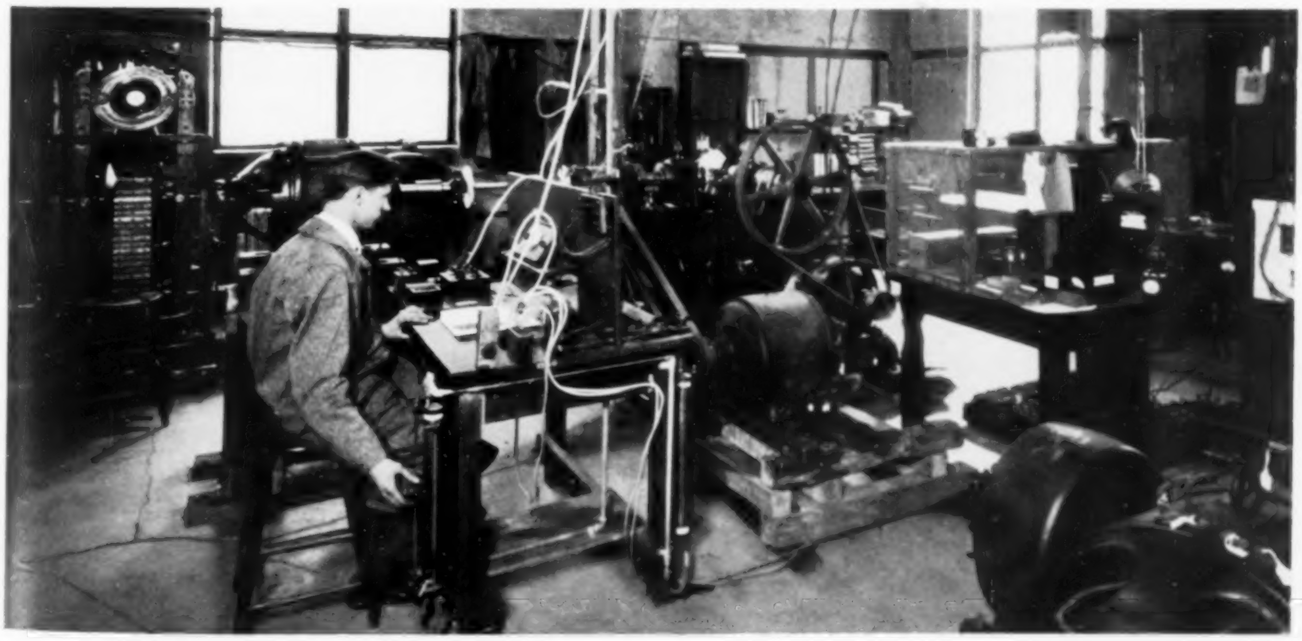
organization and the Department of Engineering Research of the University of Michigan that the latter agrees to use its best efforts to prevent the disclosure of any facts or data furnished by the client. The department has the right, subject to the approval of the client, to publish for the benefit of science such results of a given research program as are in the nature of fundamental principles.

Patent policy has also been very carefully worked out in order to provide suitable and proper protection to the client or sponsor, to the university, and to the inventor. So far as is known, the University of Michigan is the only university in the country which is in a position to advise in advance with regard to the patent policy. Four options are tendered; (*a*) full assignment to the industry in return for an extra service charge, (*b*) and (*c*) assignment to a trust company for administration to benefit all parties, and (*d*) assignment to inventor, sponsor or client having the right to use it at no cost.

A few examples of the projects completed at the Department of Engineering Research will give an idea of the diversity and scope of the work which is being carried on. One of the first large problems was to design and develop a single-phase motor suitable for general household use. After a study continuing over two years, during which the facilities of the Department of Electrical Engineering were made available, a motor of the capacitor type was designed. This motor possesses a higher starting torque, better efficiency and power factor than previous commercial designs, and it gives no radio interference (a feature very important at the present time). Since it requires a lower starting current, it does not dim the house lights when the motor is started. The fundamental features have been protected by patents under one of the above plans and at the present time it is being manufactured under license by various companies for household refrigerators and vacuum cleaners, for which it is especially adapted.

A unique phase of research which has proved valuable to industry is work on acoustics. The personnel is composed of three research physicists who have specialized in the respective fields of sound measurement, vibration phenomena, and vacuum-tube circuits. During the ten years in which this work on sound has continued the department has built up a very complete equipment of acoustical apparatus, quite adequate for even those developments of a very fundamental nature. This sound measuring apparatus measures both the frequency and intensity of any one component of noise, thereby enabling the causes of the noise to be located.

One of the important studies was of noises in vacuum cleaner motors (resulting in the marketing of much quieter machines). A rug-



ged device for the routine inspection of roller bearings in the factory has also been developed and has been used for testing for noise about 1,000,000 bearings per month for many years. Sound detecting and analyzing equipment has been used to study the causes of noises and assisted in the design of quieter gears, automobile transmissions, cream separators, and electrical refrigerators.

An X-ray department, with thoroughly modern equipment and transformer capacity up to 280,000 volts, has contributed much valuable information to manufacturers. For instance, high pressure, chrome-nickel cast steel valves weighing up to one ton were completely radiographed for the location of blow-holes and other defects. From the information obtained this manufacturer has redesigned his product so that valves are produced consistently which show no serious defects.

One of the outstanding metallurgical contributions of the Department of Engineering Research has been a study of high temperature properties of metals. This work has been in progress nearly eleven years and has involved not merely the testing of hot metals for short time properties and for creep characteristics, but also has resulted in the development of new steels possessing exceptional properties at elevated temperatures. The creep testing equipment consists of sixteen units with devices for measuring elongation accurate to half a millionth of an inch. Similar work has been conducted in special equipment to measure the flow characteristics of lead alloys used as cable sheathing.

Set-Up for Radiographing a High Pressure Valve Body With a 4-In. Wall

A study of spark plugs resulted in the discovery that the best electrodes were produced when there has been an accidental addition of less than 0.1% of barium to the metal. Routine chemical analysis did not reveal this fact, so that spectroscopic methods were used, and a special spectroscope was developed for this concern to enable its staff quickly and accurately to control the barium content of the molten metal before pouring.

Occasionally a project requires elaborate equipment outside of the university itself. A 250-ft. steel tower and a quarter-mile of experimental transmission line were erected on a hill a short distance from Ann Arbor for a thorough study of the wind forces and the effect of ice acting upon electric power line poles and conductors. This study, extending over several years, has yielded much valuable information to the power companies sponsoring the project, and the data of general interest published.

The almost unlimited scope of the problems investigated is shown by the diversity of subjects which they embrace. Work has been done or is being carried out on the scaling and burning of steels at forging temperatures (published extensively in *Transactions*, A.S.S.T.), on nickel and chromium plating, on the production of gas, the shrinkage in brass castings, on diesel engines, malleable iron, and on the physical chemistry of steel making.

The degree to which manufacturers recognize the convenience and advantage of research at universities may be measured by the extent to which they avail themselves of the opportunities. For example, in the year 1920-1921, 22 projects were investigated at the University of Michigan and approximately \$5,000 was paid by manufacturers as their share of the cost. During the year 1925-1926, 110 projects were investigated for which \$64,190 was paid; during the year 1930-31, 167 projects were sponsored at a cost of \$243,956. In the eleven years of its existence the Department of Engineering Research has conducted over 800 sponsored research projects, some of them extending as long as six years, in the fields of chemistry, physics, engineering, and metallurgy. The cost of conducting these studies totals approximately \$1,220,000.

FUELS IN HEAT TREATING FURNACES

influence of intermittent schedules on costs

By H. J. Gregg
Combustion Engineer
Surface Combustion Corp.

MANUFACTURERS of heat treated parts are now facing a constant demand for improved products at lowered costs. To meet this demand they must depend largely on careful selection of metals, improved production methods, and proper heat treatment. As one item in this chain, the fuels burned in modern heat treating furnaces must contribute to more rigid metal treatment specifications without penalizing over-all operating costs.

In general, recent furnace developments have featured automatic temperature control and continuous or cyclic operations. Up until 1929 and 1930, the common sources of heat were oil, gas and electricity—depending on the operation, the type of furnace, and the metallurgical results desired. Since the economic depression, two new phases have been injected into the question. First, the demand for high quality has emphasized the question of furnace atmospheres. The second, and perhaps most important, is economic: Fluctuating schedules and intermittent operation demand that costs be in proportion to the tonnage of product; or, in other words, that heat treating costs per pound should not run up when the plant is operating part time.

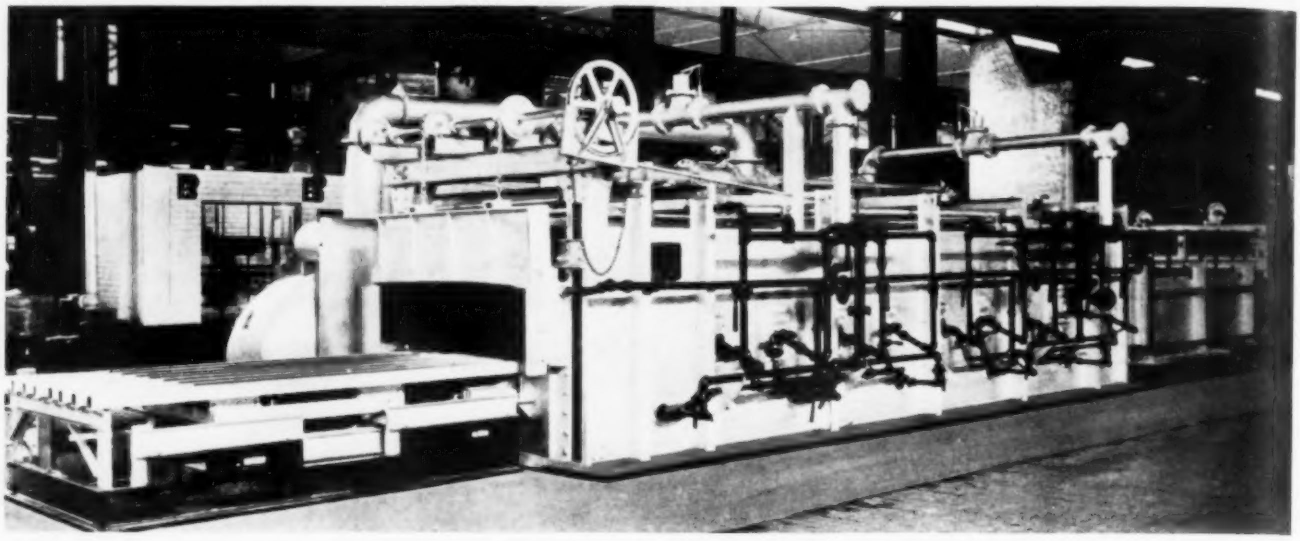
These considerations are discussed in greater detail below.

Fuel oil displaced coal for industrial furnaces because operating labor was reduced and greater flexibility on temperature control was possible. It increased in popularity, even though its cost per B.t.u. was higher than a heat unit derived from coal.

Most large manufacturers of automotive forgings now burn fuel oil in preference to other fuels for the reasons just mentioned. The process of manufacture is well standardized and products are therefore sold within close price brackets. Forging temperatures of 2200 to 2400° F. are easily produced with oil flame, and the slow burning, smoky atmospheres produce a "soft" heat and a soft scale easily broken and blown off by a steam jet or an air blast after a stroke of the hammer.

While oil-fired forges are satisfactory for hammer operations, they are definitely limited for upsetters and the modern forging presses, as will be brought out later in this article, because these practices cannot tolerate oxide scale.

Of the competing fuels for forging, electricity is generally too costly for energy and upkeep of the elements at forging temperatures.



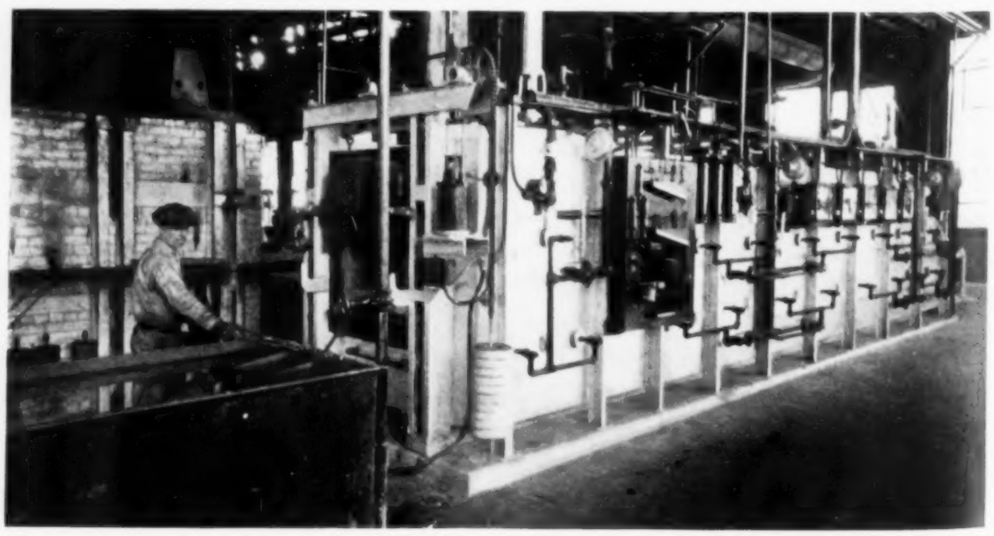
Gas has been used, but not extensively, as the cost per B.t.u. was usually higher, and most of the "clear flame" burning systems produce a thin, tenacious scale on billets, which scores the dies severely.

The inherent combustion characteristics of fuel oil lend themselves to automatic control, but the furnaces must be designed with extreme care to achieve an even distribution of temperature. It is also difficult to control the furnace atmospheres automatically. Lastly, fuel oil is not as clean nor as easy to handle as gas or electricity.

It was for these reasons that the metal industry turned to other fuels to meet demands for closer specifications on *heat treated* parts having improved surfaces (to reduce machining and assembly labor). These operations include normalizing, hardening, drawing and carburizing. Forging was not necessarily included in the list at the time. It was at this turn in events, when the automotive industry was prosperous, that electricity was promoted as a source of energy in heat treating furnaces. Electricity was doing miracles for countless other industries, and therefore it seemed to answer the specifications for a perfect fuel.

Electricity — Many batch-type and continuous furnaces have been built to perform electrically all the conventional heating operations. They are entirely satisfactory as to general operating performance, particularly from the standpoint of temperature control and distribution. Electric furnaces utilize the energy

At Top of Page: Side View of a Tin Plate Normalizer Utilizing Numerous Low Capacity Gas Burners. At the right is continuous furnace for carburizing cam shafts in a gaseous atmosphere



best, for all of the energy input goes to useful work, save the holding and radiation losses. Fuel firing has a low thermal efficiency because part of the energy input is lost in waste gases.

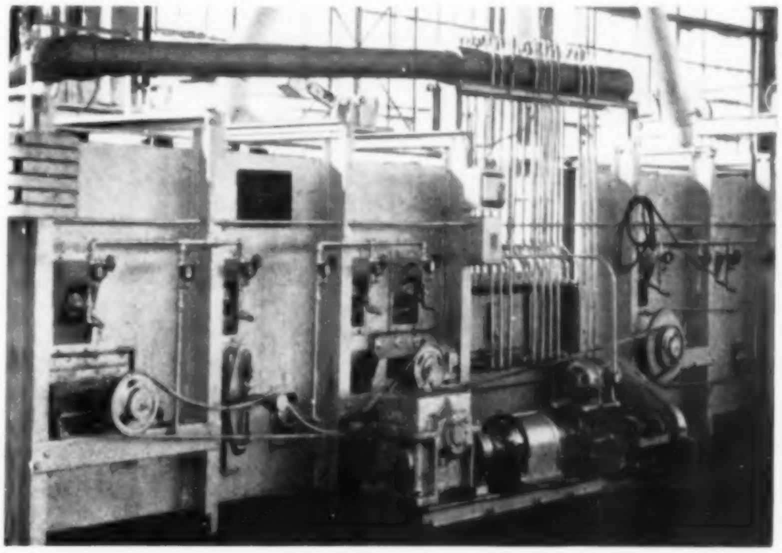
As to source of supply: Certain large factories operate their own power plants, but as a rule power is purchased. The rate invariably is of "two-part" or "three-part" nature, carrying a demand charge on connected load and a sliding scale on power consumed exceeding large blocks.

During the days of peak production, business was booming and power costs were lowest. Since 1930, however, production has been intermittent, yet metal manufacturers are compelled to pay the highest rate on electric furnace energy just at a time when increased operating costs are suicidal. Hence we find many operators completely changing their attitude in favor of gaseous fuels, and being more or less surprised to discover what progress has been made in the design and construction of gas-fired heat treating furnaces.

Artificial and Natural Gas — At the time when electric furnaces were actively replacing old oil-fired units, newer gas-fired furnaces were equally outstanding in their performances and accomplishments. There was a small problem in educating the users, for their judgment was influenced by memories of sad experience in burning natural gas with crude burners and home-made furnaces. The fuel supply did not prove dependable in winter months. They had also proved to their own satisfaction that gas-fired furnaces built by their own master mechanics and using the superintendent's "patented" burner were definitely limited in performance!

The greatest benefit and contribution have only been realized by leading furnace manufacturers in the design, fabrication, and erection of special furnaces complete, to meet the job at hand. In so doing, users have profited from all previous experiences gained in the art of correctly and efficiently utilizing artificial and natural gas fuels, with an enormous advance in furnace efficiency and characteristics.

Refined gaseous fuels lend themselves admirably to high utilization efficiencies and flexible range of turn-down under automatic control. "One valve," automatic proportioning, fuel-burning equipment is thoroughly dependable. Without limitation at reduced capacities, gas burners can efficiently burn any desired volume of fuel without that clogging or coking which occurs with low capacity oil burners. Therefore, by designing furnaces with a number of small capacity burners, an even temperature distribution is achieved, and in temperature control and heating characteristics, gas-fired units have duplicated, and in many cases definitely exceeded, the results achieved by other fuels.



Fuel Control Equipment and Conveyor Drive on Combination Normalizing and Hardening Furnace for Front Axles

Even though the efficiency of electric furnaces is inherently higher than gas-fired units, the lower cost per unit of energy with gas also influences the policy, and in most instances controls the cost per part treated. Emphasis should also be put on the clean and improved working conditions which gas enjoys, as well as electricity. What is of greater importance in recent twelve months, is the inherent advantage refined gaseous fuels possess in maintaining furnace atmosphere. Important advances have been achieved in this direction during the past eighteen months. We refer in particular to the

development of diffusion combustion and continuous gas carburizing.

Diffusion Combustion Forge Furnaces — We shall not attempt to discuss the theory of diffusion combustion nor the design of burners to produce this phenomenon, for this matter was adequately covered by Mr. Hepburn in last September's issue of METAL PROGRESS. Only the results on forging operations can be mentioned. In forge furnaces, either batch or continuous types, one can produce a definite flame length with uniform temperature throughout, maximum heating power or radiation, and can exclude air yet maintain correct proportions of gas and air for complete combustion.

For these reasons, forge furnaces burning gas in diffusion burners can heat steel to forging temperatures without any scale whatsoever! In practice, some scale is present, not from the heating operation, but from the original mill scale on the slugs or bars, or formed during the transfer from furnace and during forging and cooling. Furthermore, in drop hammer practice, some scale is produced when an air or steam blast is directed at the dies to cool them or blow scale out.

The writer believes that these results have been achieved along with the highest rates of heating ever accomplished within practical limits. At a well-known wheel company in Detroit, steel slugs for automotive wheel hubs have been heated at the rate of 143 lb. of steel per hr. per sq.ft. of hearth area.

In order to determine the importance of this development, one must comment on the future trends in forging practice itself. We predict without hesitation that a large proportion of automotive forgings will be made by "press forging" methods. Forging presses require one blow, and can even satisfactorily forge steel at low temperatures between 1700 and 1900° F. But these modern presses cannot tolerate excessive scale on the steel. Hence the importance of heating steel *free* from scale.

Collateral advantages are in reducing pickling costs to a minimum. Improved surface conditions also cut the machining costs — one manufacturer has already recorded a reduction of 25%. Accurate press work may be held to closer dimensions, which not only makes for fewer machining operations, but is also a direct saving on the weight of the raw steel purchased.

Continuous Gas Carburizing — Inasmuch as this paper deals essentially with the trend of fuels used in heat treating furnaces, it cannot discuss at length the theory and design of this new furnace. Mr. Cowan, in METAL PROGRESS, Feb., 1932, has covered the ground. It can only be said that work is charged on an open tray and pushed continuously through a muffle, using unique methods for holding a definite ratio of gaseous compounds in order to produce definite carburizing results. During the past twelve months, even in face of severe business depression, four of these furnaces have been installed for carburizing automotive parts by leading manufacturers. Results have demonstrated a low installation cost, a saving of half the ordinary floor space, low operating costs (50 to 66% under present pack carburizing methods) and adequate control of depth and character of case.

Butane — Business conditions in all branches of the metal industry demand that production and fuel costs be cut to the bone, yet in many manufacturing centers the rates for electricity and artificial gas have not yet been "deflated" along with other necessary items. To meet this economic situation, the petroleum industry has introduced a by-product known as butane, a light hydrocarbon liquefied from natural gas. It is free from sulphur, shipped in tank cars, and can be used in conventional gas-fired furnaces with equal efficiency and with all the desirable burning characteristics of artificial or natural gas fuels. It becomes a matter of costs per B.t.u. whether butane can profitably be utilized in automotive heat treating furnaces. The matter of supply and stability of price must stand careful investigation also, but this has proven entirely satisfactory to large automotive manufacturers during the past two or three years, or from the time it was first made available.

In general, it may be said that where gas is available at reasonable prices, butane can duplicate but show no appreciable savings in fuel costs. Where gas is burned, however, with high demand rates and penalties paid for small consumptions, butane has produced outstanding savings when plants are operated at curtailed capacity, for then the fuel cost is proportional to tonnage treated.

Good Re-Design Clearly Reveals Sound Construction

Re-design is not something you can smear over a finished product like a coat of paint; it is the building up of a well organized relationship between materials and the functional use of manufactured products.

Such a relationship is provided by the use of the light, strong alloys of Alcoa Aluminum for Pullmans, Gondolas, Refrigerator and Tank Car Units. Here you have the combination of a metal that is strong to bear burdens . . . yet light to move since it is only ⅓ the weight of steel yet possesses equal tensile strength. Being also an excellent conductor of heat and electricity and resistant to corrosion, the scope of use of Alcoa Aluminum is increased. It is practical for products as widely variant as washing machines, clocks, cameras, lighting fixtures, radios.

Aluminum Booms . . . Down Costs . . . Up Profits

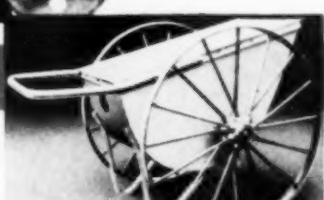
Varying in length, 110, 135, 140, 155, 170, 175 feet, lots of Drag Line Booms, made of Alcoa Aluminum, are now at work . . . handling buckets that bite up to 7 cubic yards of earth . . . which represents, fully loaded, a lift of over 18 tons . . . moving 150,000 cu. yds. a month . . . netting savings up to 2.53¢ each cu. yd. Drag Line Buckets too, are made of Alcoa Aluminum. Results . . . cleaner dump . . . 33% increase in capacity of moderate size drag lines.

Color Now Added . . . Integral with Aluminum

By a new process, called "Alumilite" . . . color is added to the surface of Alcoa Aluminum articles of all kinds. . . Brilliant reds, blues, greens and other colors are obtainable, and these are virtually part of the metal itself. Alumilited finishes are many times as resistant to abrasion as enamel and other common metal finishes . . . resistant to oil, food stains and finger markings. Articles produced from sheets, sand, permanent mold and die castings, drop forgings and extrusion presses . . . may be Alumilited.

Designed in Aluminum . . It weighs 37 . . instead of 85 lbs.

This Wheelbarrow *now* holds 4 to 5 cu. ft. of sand. Re-designed in Aluminum, the Concrete Cart, in the foreground, *now* weighs 85, instead of 225 lbs. At 50 trips per day the new Cart increases pay load 7000 lbs. Being Alcoa Aluminum, both Containers are corrosion resistant . . . non-toxic. Now used in Building Industry . . . should also be used in Chemical and Food Industries.



ALCOA ALUMINUM

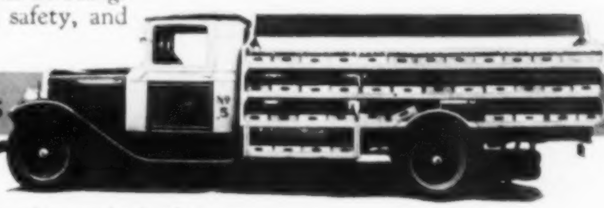
Now "Time's" Hands Will neither Rust nor Vibrate

. . . and is Father Time grateful? And that's not all he gains from Alcoa Aluminum. Its light weight means that his huge hour and minute hands can be erected with less counter balancing to throw its load on the clock's central shaft. These clock hands are made of 14 gauge Alcoa Aluminum Sheet, welded and bolted to a framework of 1" x 1" x 1/8" aluminum angles . . . faced with glass, behind which is a row of electric light bulbs.

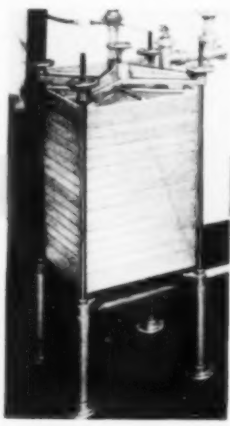
4300-foot Mississippi River Crossing . . . with A.C.S.R.

This is a double circuit span of 307,500 c. m. aluminum cable steel reinforced, built by Arkansas Power & Light Company and Memphis Power & Light Company. Designed to insure safety and to provide a clearance of 75 feet above river surface in super-flood conditions. Towers are 435 feet high. Cable of Alcoa Aluminum, of course . . . it alone brings the combination of light weight, safety, and economy.

Re-Designed . . . Carries 25 More Cases



Made of Alcoa Aluminum, this Bottlers Truck Body is immune to rust even though the bottles may be trucked when wet . . . which of course is almost unavoidable. Decks are of corrugated sheet . . . deck posts set in to adjust stresses. The re-design in Aluminum stepped up the load from 126 to 151 cases at no increase in total weight on wheels.



Re-Designed . . . It Conducts Heat Quickly

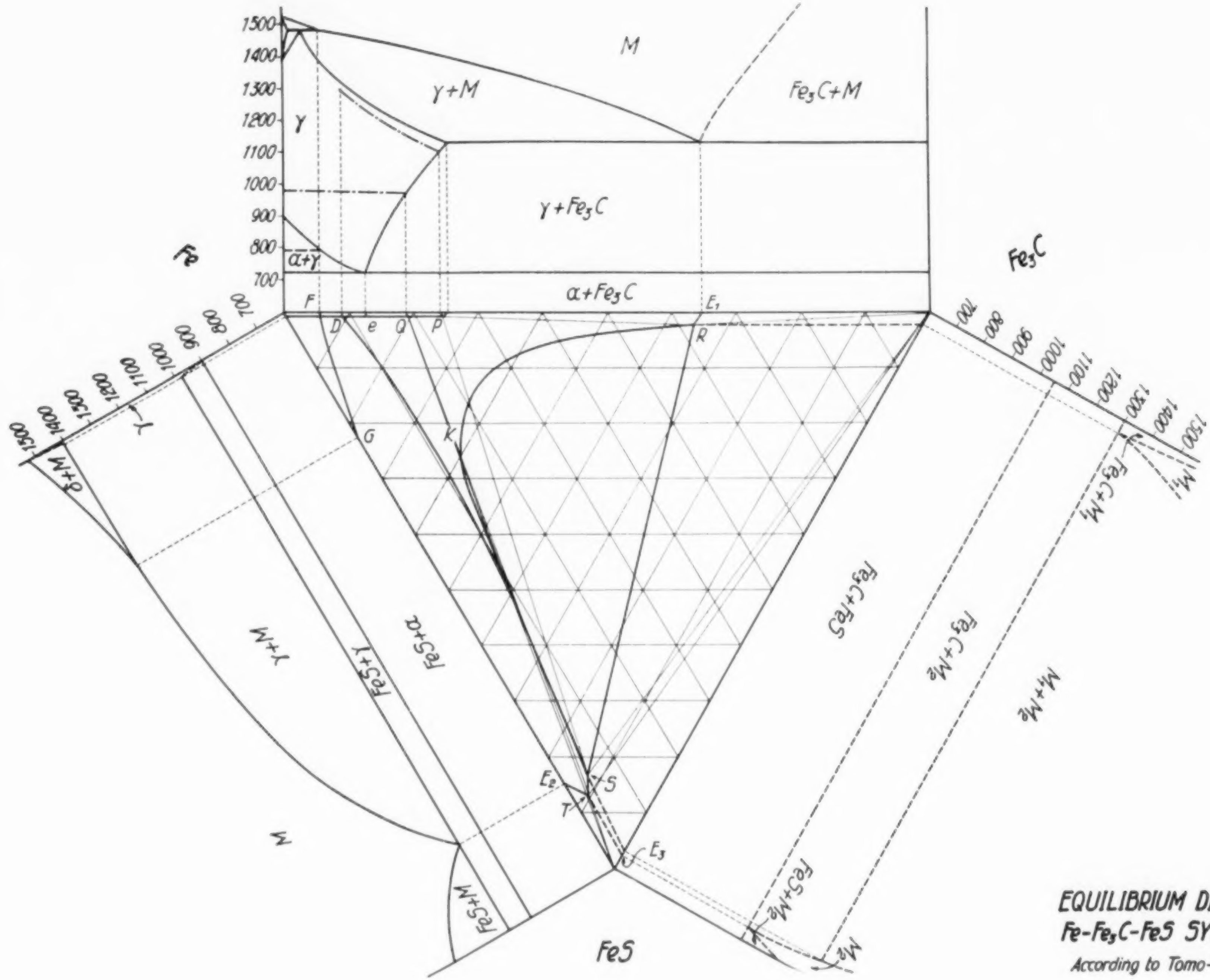
This Plate Heater is made entirely of Alcoa Aluminum Castings. Results . . . high heat conductivity and light weight which mean handling with minimum effort . . . plates retain polish and are easily cleaned . . . metal is safe to use with milk and milk products . . . entire heater is cheaper, made of Alcoa Aluminum, than if made of any other metal suitable for handling milk. And there is *no need* for replating or recoating.

Facade . . . of Alcoa Aluminum Extruded Shapes

More than 150,000 lbs. of Alcoa Aluminum are used on the facade of this 7 story Building . . . used for exterior interlocking mullion assembly, cornice, flashings, louvres, copings and plinth blocks as well as windows. Pilasters and other ornamentations are fabricated entirely of extruded Alcoa Aluminum sections. Inset picture shows extruded aluminum window and mullion construction and erection method.

possessing their specific advantages. Quick deliveries from warehouse stocks in principal cities. Ask for name of your nearest distributor. For information on how to use, form or handle Alcoa Aluminum in any way, write us. Address ALUMINUM COMPANY *of* AMERICA; 2501C Oliver Building, PITTSBURGH, PENNSYLVANIA.

ALUMINUM



EQUILIBRIUM DIAGRAM
Fe-Fe_3C-FeS SYSTEM
According to Tomo-o Satō

Iron-Carbon Alloys Containing Much Sulphur

SENDAI, *Japan* — Two compounds, iron sulphide and manganese sulphide, have been found to co-exist in steel and cast iron, but exact knowledge of the phase change of these compounds at high temperatures has been lacking. Tomo-o Satô undertook to study this problem, and, as the first step, he investigated the equilibrium diagram of the Fe-Fe_3C-FeS system.

Since iron sulphide is readily oxidized and the oxides which are formed considerably alter the melting points and the structures of Fe-FeS alloys, the sulphide and the white cast iron used were prepared as pure as possible. These materials and electrolytic iron were then melted together in a Tammann furnace; oxidation of the melt was prevented by covering it with a mixture of glass and sodium carbonate. In this manner 75 different alloys were prepared and studied by thermal analysis. The diagram on the data sheet opposite shows the result of this investigation.

In the carbon-rich alloys near the Fe-Fe_3C side of the ternary diagram the break point in the cooling curves corresponding to the binary eutectic point appears below 1130° C. They also halt slightly at 1100 to 1110° C. By increasing the sulphur content, the alloys do not show the eutectic point, but have two halting points at 1100 to 1110° and 970° C. respectively.

Microscopic investigation of these alloys showed that those containing a considerable amount of carbon and sulphur have a ternary eutectic, rich in iron sulphide, in a globular form. It was ascertained that alloys in certain composition ranges do not melt into a homogeneous phase, but separate into two phases and that the monotecto-eutectic reaction takes place at 1103° C. and the phase containing a smaller amount of sulphur finally disappears. It was also discovered that the remaining sulphur-rich phase solidifies as a ternary eutectic, separating gamma iron, cementite, and iron sulphide. The monotectic reaction curve and the ternary eutectic point as determined by Hanemann and Schildkötter agree satisfactorily with those determined by Satô.

The primary crystallization curves and the eutectic point in the equilibrium diagram of the Fe-FeS system agree with those of former investigators, but the existence of a transformation point at about 1400° C. in the alloys containing up to 23% FeS was discovered. In considering the structure of the ternary alloys, it was assumed that iron dissolves a small amount of iron sulphide as a solid solution in the vicinity of the transformation point, which causes a peritectic reaction at the point not far from the A_4 point of iron.

Furthermore, iron sulphide was found to have two polymorphic transformation points at 135° and 308° C. respectively; these transformations were also observed in Fe-FeS and Fe-Fe_3C-FeS alloys. The qualitative binary diagram of the Fe_3C-FeS system shown in the figure on page 44 was also deduced from the diagram of the ternary system.

KOTARO HONDA

Test Files Made of Nitrided Steel

TURIN, *Italy* — The problem of determining scratchardness, using properly made files, has been given great attention in Italy, especially by Fabbrica Italiana Lime di Precisione of Turin. "F.I.L.P." is now one of the largest and best equipped file factories in Europe.

This problem has been considered twice in METAL PROGRESS, first in an editorial in September, 1932, and again in December in a very interesting and authoritative article from the research laboratory of the Nicholson File Co. Therefore, it may be interesting to quote some of the results obtained by "F.I.L.P.," as they do not completely correspond with those from the Nicholson company.

In the first place, a vast number of tests

were made on steels of very different compositions and treatments in order to compare the indentation hardness (as determined by the Vickers diamond apparatus) and the scratchardness (determined by the diamond scratch test, first introduced by Martens, and developed by Turner) with the file hardness. The latter was determined by files manufactured by a process under rigid control from steels of various compositions, hot worked and heat treated with precision. At the same time, the brittleness of the steels was determined.

Complete results of these tests cannot be reproduced here, for obvious reasons, but in a general way the scale of file hardness for tough-hard materials (such as some hardened alloy steels) parallels generally the scale of indentation hardnesses, while variations of file hardness on brittle-hard materials (hardened high carbon steels) have a marked tendency to follow those determined by the diamond scratch test.

The experiments noted above give a more exact definition to a fact already known, somewhat indefinitely, to file testers. A hint to this effect can be found in the article by the Nicholson File Co., where it is said: "Alloy steel is denser and would, therefore, resist the file a little differently and it would be necessary to have a test piece of the same or similar material."

In the editorial it was suggested that files of greater hardness might be made of nitrided steel, but the Nicholson company said that superhard files were not commercial. The latter does not conform to our experience, for in order to test very hard materials, up to Rockwell C-68 and more, files of nitrided steels are being made.

By properly eliminating the superficial layer of nitrides (the "I-nitride" and "II-nitride," so called by Fry) and by choosing a correct type of nitriding steel, the files can be made so they show a very constant hardness. The regular 1% aluminum steels were excluded, on account of the brittleness of the nitrided teeth. Other well-known low aluminum steels, and some of the nitriding steels without aluminum, regularly produce files of a given hardness, up to 1000 Brinell-Vickers. These can be used to determine rapidly the hardness of very hard steels, within sufficiently narrow limits.

A careful study of the form of the teeth showed the great influence of design upon the problem of obtaining a good nitrided file for hardness testing. It should be obvious to file makers that more constant results can be obtained by making at least one cut by the machine known under the French name "raclette," and by choosing an accurate tool giving a special form to the teeth.

As it is pointed out in the article of the Nicholson File Co., similar results (though limited to certain hardnesses, and not so constant or exact) can be obtained with files made by the normal processes — that is, with files made of special high carbon steels, usually containing various percentages of chromium and tungsten, and properly hardened. Fabbrica Italiana Lime di Precisione regularly makes these testing files of different hardnesses, but it is thought that the nitrided files will probably give better and more reliable results, provided the necessary care is given to the choice of the steels to be used, the manufacturing process, and the form of the teeth.

FEDERICO GIOLITTI

Three More Letters About Magnetic Hardening

CHARLOTTENBURG, *Germany* — As a contribution to the discussion of E. G. Herbert's work on the influence of magnetic fields on the aging of hardened steel, the investigations on the same subject which were made by Dr. Kussmann and the present writer at the Technischen Hochschule, Berlin, should be of interest. A full account of these was published last September in *Stahl und Eisen*.

In his experiments Mr. Herbert has combined the action of the magnetic field with a

heating to 100° C. Furthermore, he often has cold hardened the specimen by the so-called cloudburst method — that is, bombarding the sample's surface with falling steel balls. Since annealing at 100°, as well as cold hardening, may likewise induce some change in the material, we felt that the influence of the magnetic field alone on the aging of hardened steel should be investigated.

For our experiments we used three plain carbon steels with 0.72%, 0.90%, and 1.06% C. In order to avoid decarburization they were heated to the hardening temperature in a vacuum and quenched in water, after which the surface was smoothly ground and polished. By adjusting the gap between the poles the electromagnet used was capable of a field strengh of 7000 oersted, which is sufficient to magnetize the samples to the saturation point.

Hardness was measured with a Rockwell machine with a diamond penetrator. In order to bring the tests as closely as possible into correlation with Herbert's conditions, we also used a pendulum hardness tester; our pendulum tester had a steel ball instead of a diamond point. However, since it was a reliable instrument and gave hardness numbers comparable to the Rockwell values, no basic error was thus introduced. Before beginning the measurements it was determined that the oscillations of the pendulum hardness tester were independent of the magnetic state of the test pieces, and that both testing machines gave parallel results.

A number of samples were tested which had been quenched under identical conditions and then stored for several days at room temperature, until the changes due to aging — proceeding rapidly at first — had died away. The results of these experiments, which included a large number of individual measurements, showed indisputably that diamagnetization and drawing the sample through a magnetic field at room temperature induced no measurable change in either its pendulum hardness or its Rockwell hardness. Furthermore, after another period of seasoning at room temperature, the magnetically treated samples showed no difference in hardness from those not magnetically treated. An example of these measurements and an indication of their accuracy is given in the attached table.

Influence of Magnetic Treatment on a 0.72% Carbon Steel Quenched and Seasoned Several Days at Room Temperature

Sample 1 Time Hardness		Sample 2 Rockwell Hardness, C Scale	
66.4, 66.0, 68.0, 66.5, 66.6 66.0, 64.8, 66.2, 66.2, 66.7	Av. 66.3	61.2, 61.0, 61.5 61.0, 61.3	Av. 61.2
Above, after 50 turns in a magnetic field of 7000 oersted			
66.2, 66.0, 65.2, 65.7, 67.4 65.2, 65.2, 66.4, 67.1	Av. 66.1	61.2, 61.0, 60.8 61.5, 61.0	Av. 61.1

Another point which was investigated was the question of whether the magnetic treatment strengthened the effect of an anneal at 100° C. A number of freshly quenched steel samples were boiled in water for several minutes, and during this time they were treated magnetically. Comparison pieces were heated identically but without magnetic treatment. Hardness tests then showed that (within the accuracy of the test) no additional effect of the magnetic field was to be observed. In both groups the Rockwell hardness was raised about 1.5 units, and then remained constant when stored at room temperature.

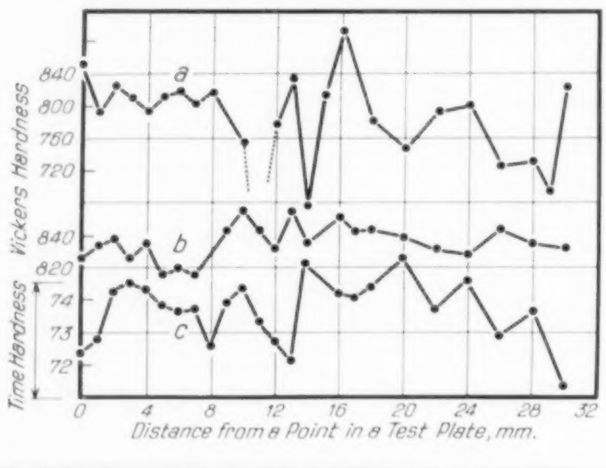
These experiments seem to prove that the hardness of a hardened carbon steel is not raised by magnetic treatment alone. If the magnetizing is done at a temperature of 100° C., a slight increase in hardness occurs, which, however, is attributed to the heating action alone and not to the magnetic treatment. Likewise, preliminary magnetic treatment had no observable influence on the further progress of the aging of our steels. H. J. WIESTER

SENDAI, *Japan* — E. G. Herbert has recently reported in several papers that when a steel is quenched or hardened by the "cloudburst" method, subsequent rotating in a strong magnetic field will further increase its

hardness. He also extended his work to non-magnetic substances and confirmed the increase of hardness, though it is small. These results are very novel, but do not agree with our experience; hence I have repeated the same experiments with great caution, and have come to a negative result.

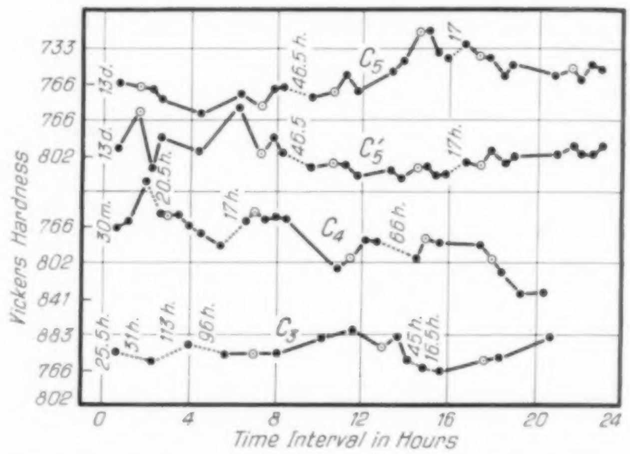
There is always a local variation of hardness in a quenched steel amounting to several per cent; hence for an accurate investigation of age hardening of a specimen, it is necessary to observe the changes in hardness at the same point. Actually this is not possible, because the measured point is more or less damaged. The best that can be done is to make allowances for the local variation of a quenched steel, as is shown in Fig. 1.

Fig. 1 — Uniformity of Hardness in Specimen of Quenched Steel Measured With Vickers Machine and Pendulum



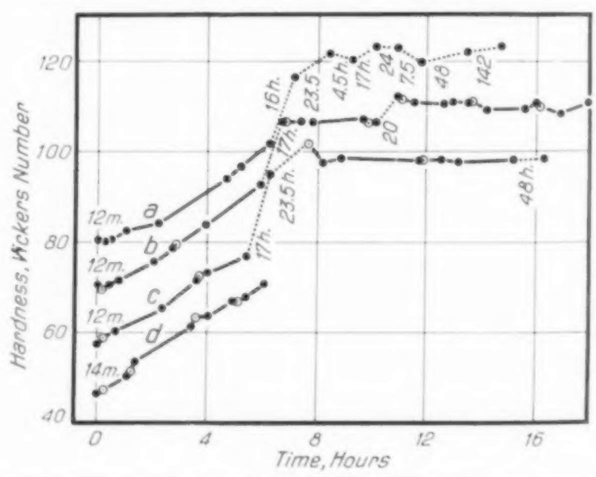
Figures 2 and 3 show age hardening curves for a 0.6% carbon steel and duralumin respectively; the former was quenched from 790° C. (1450° F.) and the latter from 500° C. (930° F.). In these curves the circles with dots in the center show the hardness measured immediately after magnetic treatment at 100° C. in a field strength of 6000 to 7000 gauss. (In other words, a given sample was subjected to the magnetic field more than once, after it became evident that the hardness was not changing measurably.) The figures written along the broken lines show the time interval passed between two neighboring points. The figures at the beginning of each curve show the time interval passed after quenching.

Fig. 2 — Time-Hardness Curves of Steel, Quenched, Magnetized, and Aged



Examination of these curves indicates that the magnetic treatment can have no effective influence on the hardness of non-magnetic or magnetic substances. There are small fluctuations in the curves, but their magnitude does

Fig. 3 — Time-Hardness Curves of Quenched Duralumin. Curve a was not treated magnetically; the others were



not exceed 5 to 6%, which is within the expected local variation of hardness. Hardness of duralumin increases rapidly for some hours at the beginning, as shown in Fig. 3, but this is not the effect of magnetic treatment, but is due to the well-known age hardening of quenched duralumin. The increase of hardness in duralumin, when quenched but not magnetically treated (curve *a*), is of the same order of magnitude as that when magnetically treated after quenching (curves *b* and *c*). Moreover, no regular change of hardness, which can be taken as the effect of the magnetic treatment, can be seen in the curves in these figures.

YOSHIHARU MATUYAMA

MANCHESTER, *England* — It is to be regretted that Mr. Matuyama, who had access to the two hardness testers, should have chosen the Vickers machine rather than the Herbert pendulum. The essential difference between these two systems is that the pendulum measures hardness under load, and takes account of both elastic and plastic deformation. The Vickers machine measures plastic deformation only. It has been found capable of revealing hardness changes produced by suitable magnetic treatment, but is incapable of indicating changes in the elastic properties of metals, and there is reason to believe that elastic changes are principally (though not exclusively) involved during and after magnetic treatment.

In this, as in other respects, investigators should reproduce the original experimental technique when checking the validity of results of unusual character. The whole of my magnetic experiments have been made with magnets having an air gap 3 mm. wide, the specimen (generally not larger than 15x15x2 mm.) being placed in contact with the pole pieces, bridging the gap, and being rotated in that position. The strength of field in the gap was from 6000 to 27,700 gauss. This equipment and technique is clearly shown in my article entitled "Hardness Changed by Magnetism" in METAL PROGRESS for April, 1932.

Mr. Matuyama has rotated his specimen in the center of a wide air gap in a field of 6000 to 7000 gauss. I have made no experiments under similar conditions, but I should not expect them to succeed.

It is, of course, granted that metals have local variations in hardness, and they should be provided for by properly preparing the surfaces of specimens, as uniform as possible, and averaging a sufficient number of readings. This has always been done in my experiments.

Some question has been raised as to the damping effect of a magnetized specimen on the pendulum swing. It has been my practice to eliminate this effect by placing the specimen on a heavy iron support (which short circuits the external field) and with the direction of polarity at right angles to the plane of oscillation (the field then has no effect on the rate of swing, even if not short circuited). My results are therefore in no way influenced by the field of the specimens.

My hardness measurements are made with the pendulum. My results can be and have been reproduced by other workers using the pendulum. They have also been reproduced by other tests, including the Vickers. Nevertheless I can take no responsibility for the disabilities of any hardness testers other than those used in my experiments.

EDWARD G. HERBERT

Red Hardness of Cutting Alloys

LONG ISLAND CITY, *N. Y.* — The articles by Messrs. Jeffries and Sykes in the February number will be appreciated by all as giving fairly complete information on a new type of cutting tool alloy. There is, however, one point on which the average reader may be misled. This concerns the meaning of the term "red hardness."

Red hardness has been generally accepted

as meaning the hardness of a metal or alloy as measured while the sample is held at a temperature in the red range. It has no definite relation to the hardness as measured cold except that the hardness hot is usually less than the hardness cold. Some experimenters have more recently preferred the term "hot hardness," inasmuch as this extends the meaning of the term over all ranges of temperatures either within or without the red range.

On page 34 of the February article Mr. Sykes refers to Fig. 3, which apparently shows the hardness measured while cold on samples after they had been heated for various periods of time at 600, 700, and 900° C. He follows this with the statement, "This property of retaining hardness at high temperature is known as 'red hardness.'" In view of the generally accepted meaning of the term, Fig. 3 does not express red hardness unless we assume that the hardnesses indicated were measured at temperatures corresponding to that of the curves. This was not stated, and the inference is that the hardnesses were measured after the samples had cooled to room temperature. W. A. Wissler

The question raised by Mr. Wissler is undoubtedly most pertinent, and he is correct in assuming that all the measurements of hardness were made at room temperature.

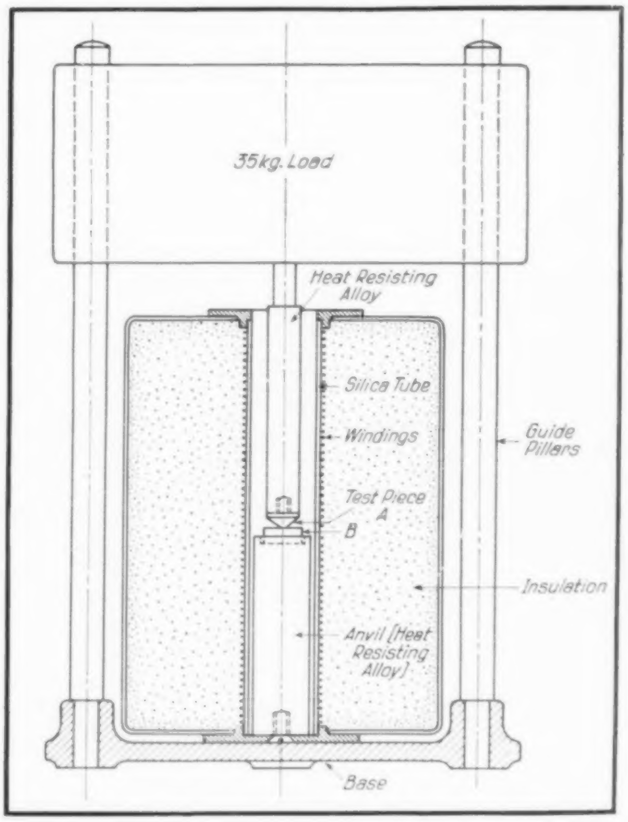
I agree that the term "red hardness" should be applied only to the hardness of a material as measured at the elevated temperature. While there may be no definite relation between the "red" and "cold" hardness of a metal or an alloy it appears likely that a high "cold" hardness which results from precipitation hardening at 700° C. would indicate a relatively high "red hardness."

Such a statement, I trust, describes more accurately the conditions represented by Fig. 3 of the article in last month's Metal Progress, and I sincerely regret having issued any misleading information. W. P. Sykes

Measuring Hardness at High Temperatures

Sheffield, *England* — A method for determining the true hardness of metals at high temperatures, which enables the results to be expressed as Brinell numbers, has been developed by the undersigned, chief metallurgist of Darwins Limited, and this may be interesting to American experimenters.

The sample to be tested is made into the form of a small cone (*A* on the attached sketch) with an included angle of 120°. This rests on an anvil and is submitted to a load of 35 kg. for a period of ten days. The anvil, cone, and plunger are surrounded by a small electric resistance furnace and can be maintained at any desired temperature up to 1150° C. (2100° F.),



Sketch of Furnace and Press for Heating Specimen and Flattening Its Nose Against an Anvil

the temperature being controlled by any of the usual commercial mechanisms. The anvil cap *B* is made from a hard heat resisting metal containing approximately 60% nickel, 20% chromium, and 7.5% aluminum. Provision is made for maintaining an inert atmosphere.

Under the combined effects of pressure, time, and temperature, the apex of the cone flattens out and the area of contact between it and the anvil face steadily increases. Equilibrium is usually reached in about 100 hr., but it is advisable to allow a considerable factor of safety, and in our experiments the test is maintained for ten days. The hardness number is derived exactly as in the Brinell test; that is, the area of the flattened surface on the cone in square millimeters is divided into the load in kilograms. Above 700° C. (1300° F.) practically all metals (with the exception of cemented tungsten carbide and a few peculiar alloys which depend for their hardness upon the presence of compounds of aluminum with a metal of the iron group) appear to have a Brinell hardness considerably less than 10.

In the case of an alloy containing 28% chromium and 0.3% carbon, the Brinell hardness at 800° C. (1475° F.) was found to be 1.5. The creep stress of that metal at 800° C. is approximately 700 lb. per sq.in. (0.50 kg. per sq.mm.). If one assumes that the relationship between Brinell hardness and ultimate strength is the same at all temperatures, one would anticipate a Brinell hardness of approximately 1.5 at heat, but previous investigators have always found much higher values.

While at first sight it may appear inaccurate to express the figures obtained with this machine as Brinell hardness, experiments have shown that if instead of carrying out the hardness test as the Brinell method, the test piece in the form of a cone with an angle of 120° is pressed against a hard steel plate, the pressure per square millimeter on the flat surface thereby formed on the cone is in close agreement with the Brinell hardness numeral.

J. Ferdinand Kayser

Non-Destructive Analysis

Paris, *France* — A frequent practical problem is to analyze or identify a metal without destroying or spoiling it — for example, a finished piece which may be made of the wrong metal, or a machine part of a foreign, an unknown, or a competitive fabrication.

Chemical analysis usually dissolves a sample of metal taken from the piece. Mechanical tests are seldom characteristic, and usually cause a lasting deformation even if they are not carried to the breaking point. Determination of the physical properties (elastic, electric, magnetic) is carried on without deterioration of the metal, but generally requires a simple test piece which must be taken from the piece under investigation. These physical and mechanical properties are often considerably modified by past history and heat treatment, and this introduces many uncertainties into the result, but may be sufficient if it is enough to determine one from among a small number of well-defined metals and alloys.

Non-destructive analysis or identification therefore narrows down to: (1) Some process requiring (or modifying) an extremely small quantity of matter and leaving a barely perceptible trace upon the surface, or (2) when the piece cannot bear even this, to some procedure leaving the surface entirely undamaged.

Belonging to the first class are all the localized hardness tests (sclerometer, Moh's scale, diamond needle, indentation of very small ball or cone under a slight load, scleroscope), corrosion tests (etching speed under an acid drop, coloring by etching, touchstone), and micrographical examination. In the second class may be placed the determination of density (which may give some information in extreme cases of the presences of tungsten in steel or magnesium in extra-light alloys), of the elastic properties, or of surface properties such as the thermoelectric power — a discrimination must be made between the nickel steels and the ordinary steels having the same hardness — *(Cont. on page 54)*

CORRESPONDENCE

(Continued from page 52) and measuring coloring changes by means of the photo-electric cell in monochromatic light.

All these tests are but *indirect* ones and require much knowledge about the connection between the properties and the chemical analysis. There are, however, two methods whereby some elements in alloys and more particularly in steels may be detected *directly*, both in a qualitative and a quantitative way.

First is the spectroscopy of sparks; comparing them with the spectra of those elements which are sought.

This has the advantage of showing the presence, even in very small quantities, of elements which have very little effect upon the mechanical properties or the micrography of steel. For instance, the spectroscope detected the presence of aluminum in some mild steel sheets, some regions of which could not be galvanized in a satisfactory way, when the microscope showed nothing.

The second manner of proceeding is by electrolytic impression. In this a reactive paper and a metallic plate are laid against the piece under study. The paper is soaked in a conductive solution containing a reagent giving a characteristic colored precipitate with the element which is sought in the metal. Then an electric current is imposed, the piece being the anode.

Presence of nickel is revealed in steel within 5 to 15 sec., using a 6-volt current and a gelatined paper soaked with the following reagent: 20 c.c. common salt solution (20 grams per liter), 10 c.c. sodium acetate solution (20 grams per liter), 10 c.c. tartaric acid solution (20 grams per liter), and 10 c.c. alcoholic solution of dimethyl-glyoxime (0.50%).

The paper is then washed; when the steel contains some nickel a characteristic rose coloring is obtained, the intensity of which permits one to estimate the percentage. It is possible that similar methods can be used to give a fair approximation of the chromium, cobalt, tungsten, and molybdenum in steels.

ALBERT PORTEVIN

ASK FOR THESE USEFUL PAMPHLETS

Extensometer

A simple but rugged extensometer has been developed by Union Carbide & Carbon Research Laboratories. A booklet describes how it works and how to use it for determining either yield point or as a strain gauge to show elongation under specified load. Bulletin Ma-63.

High Cr Cast Iron

A pamphlet describing foundry production of cast irons containing from 15 to 30% of chromium has been issued by Electro Metallurgical Co. These cast irons do not grow or scale after repeated heatings and are excellent for high temperature work. Bulletin Ma-16.

Architectural 18-8

A fund of valuable information on the architectural application of Enduro stainless steel is contained in a brochure of Republic Steel Corp. Facts are presented on the fabrication, properties, shapes and finishes available. Well illustrated. Bulletin Ma-217b.

New Welding Method

Bundy Tubing Co. offers a 16-page "picture book" giving the complete story of the spectacular process of production welding without flame or arc by their new hydrogen electric process. Photomicrographs showing structure of welds, proof of strength, applications, etc., are presented. Bulletin Ma-93.

Alloys of Aluminum

Data and tables describing the physical properties and chemical constituents of the several alloys of aluminum are presented in a carefully prepared booklet issued by Aluminum Co. of America. An authoritative discussion of these alloys. Bulletin Fe-54.

Beryllium Copper

A new copper alloy possessing excellent physical properties which may be greatly improved by heat treatment is described in a booklet of American Brass Co. Adding 2.25% beryllium to pure copper produces the remarkable properties described in the booklet. Bulletin Ma-89.

Furnaces and Burners

Photographs and descriptions of practically every type of heating furnaces are contained in a folder recently put out by Surface Combustion Corp. to describe its scope of activities as manufacturers of standard and special furnaces and burners. Bulletin Fe-51.

Heat Treating Data

Brief but accurate summaries of the proper treatments for annealing sheets, wire, welded tanks, malleable castings and forgings are given in a book published by Brown Instrument Co. Normalizing, tempering, hardening and carburizing recommendations as well as many special treatments are included. Bulletin Fe-3.

Stabilog

Continuous rather than batch processes are controlled at all times by Foxboro Co.'s new Stabilog, in which a differential pressure motor moves the throttling range of the master valve in anticipation of variations in the rate of change at the controlled point. A booklet thoroughly describes it. Bulletin Fe-21.

Ingots of Quality

Their new ingot stripper produces fine big-end-up ingots at lower cost than is now experienced in producing ordinary ingots of indifferent quality, says Gathmann Engineering Co. in a new booklet. Operation is economical even when the plant runs at only 10% of capacity. Bulletin Ja-13.

Turbo Compressors

A series of three bulletins is available from Spencer Turbine Co. describing their Turbo Compressors for oil and gas fired equipment and foundry cupolas. Sizes range from 100 to 2,000 cu. ft., 1 to 300 h. p., 8 oz. to 5 lbs. Bulletin Fe-70.

Furnace Parts

Various parts for furnaces made from alloys manufactured by Driver-Harris Co. are pictured and described in an interesting publication. Complete performance data and specifications of Nichrome and Chromax heat resisting alloys are given in the booklet. Bulletin N-19.

To Prevent Rust

The well known rust preventive, No-Ox-Id, is now available from Dearborn Chemical Co. as a foundation for paint. It is available in the colors red, gray or black. A booklet explains how maximum resistance to corrosion can be obtained. Bulletin Ju-36.

Welding Mn Steel

Metal and Thermit Corp. offers a new bulletin describing the Murex method of welding manganese steel which utilizes a heavily coated chromium-nickel rod for a strong, ductile joining material and overlays it with wear-resisting manganese steel containing a little nickel. Bulletin Fe-64.

How to Test Wear

Tests of lubricants or of wear of moving parts may be made accurately with a new machine, made by Timken Roller Bearing Co. A bulletin tells how the machine tests the load carrying capacity of lubricants and measures the friction and wear of materials. Bulletin M-71.

Cut Forging Costs

An 8-page reprint has been issued by Electric Furnace Co. which illustrates various types of automatically controlled continuous, semi-continuous and batch type forging furnaces and shows the advantages and savings effected by the installation of modern forging furnaces. Bulletin Ja-30.

Allegheny 46

This alloy has strength at high temperature and couples corrosion resistance with ease of fabrication. Allegheny Steel Co. has issued a bulletin covering the chemical and physical properties of this low alloy heat and corrosion resisting steel which has many applications in furnace equipment. Bulletin Fe-92.

Scleroscopes

The model D standard recording scleroscope is described and illustrated in a recent publication of Shore Instrument Co. The theory and practice of hardness testing with this portable machine as described in this bulletin reveal a fund of valuable facts. Bulletin S-33.

Q-Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in one of that company's publications. Bulletin D-17.

Cyanides and Salts

Metallurgists will find valuable information in an 80-page booklet published by R & H Chemical Department of E. I. du Pont de Nemours Co. Technical information on the heat treatment of steels with cyanides and salts is presented in a lucid manner. Bulletin D-29.

Recuperators

The complete story of recuperators built by Carborundum Co. for industrial furnaces is told in a readable booklet. The range of types available is described and the operating conditions are outlined in a clear manner. Bulletin F-57.

Nickel Steel

International Nickel Co. is publishing an illustrated newspaper called "Nickel Steel Topics" which contains technical, semi-technical and news articles dealing with the production, treatment and uses of nickel alloy steel. Bulletin Ju-45.

Refractories

A semi-technical booklet prepared by Norton Co. gives valuable information on the manufacturing processes and the various industrial applications of fused alumina (Alundum), silicon carbide (Crystolon) and fused magnesia refractories products. Bulletin J-88.

Globar Elements

Globar electrical heating units and a variety of accessories for their operation have been catalogued by Globar Corp. A list of the standard industrial type heating elements and a coordinated list of terminal mountings and accessories is included. Bulletin N-25.

Liquid Baths

A competent discussion of liquid baths for heat treating steel at temperatures from 350 to 1800° F. appears in a recent publication of E. F. Houghton & Co. A valuable chapter is devoted to the proper design of furnaces for use with liquid baths which lists 20 general furnace requirements. Bulletin Ja-38.

Titanium in Steel

An elaborate catalogue prepared for technical readers describes the use of ferro-carbon titanium in steel. Titanium Alloy Manufacturing Co. prepared it. The application of titanium in steels for forgings, castings, rails, sheets and plates is thoroughly described. Bulletin J-90.

Homo Tempering

The use of the Homo furnace in tempering is described in detail in a booklet prepared by Leeds & Northrup Co. Photographs and data show the range of sizes in the line of Homo furnaces. Emphasis is laid on the advantages of the Homo method of tempering. Bulletin D-46.

Super Blowpipes

The advent of natural gas has made the replacement of many burners imperative. American Gas Furnace Co. describes in an illustrated folder blowpipes, ribbon burners, cross-fires, hand torches, etc., which are suitable for use with natural gas, propane and butane. Bulletin Ja-11.

New Microscope

A new low power binocular microscope is offered to metal men by Carl Zeiss, Inc. A booklet to describe it has been prepared. The new microscope is valuable in examining fractures, surfaces, etc., at magnifications from 4 to 31 diameters. Bulletin MIK-464e.

Heating Units

An unique and very useful device for calculating heating units when figuring coiled units, covering wattages from 275 to 1000, has been prepared by Hoskins Mfg. Co. Two slotted cards are clamped back to back through which various data can be read by adjusting a card which slides between. Bulletin D-24.

Atmosphere Control

Furnaces equipped with "Atmosphere Control" as manufactured by Hevi Duty Electric Co. are described in a new bulletin. Operation of the atmosphere control device is described and specifications are presented. Bulletin Ja-44.

Darkfield Microscopy

Comparison is made of darkfield and brightfield metallographic examination in a 16-page publication of E. Leitz, Inc. The equipment necessary for darkfield microscopy is described and prices are given. Several sets of micros of the same field contrast the two methods of illumination. Bulletin Ja-47.

Fatigue Testing

That much discussed topic — fatigue testing — is covered in a publication of Thompson Grinder Co. Interesting data on fatigue of metals and a description of the rotating beam type of fatigue testing machine are presented. Bulletin D-23.

Cast Vanadium Steel

Jerome Strauss and George L. Norris have written a technical booklet for Vanadium Corp. of America describing the properties developed by steel castings containing various percentages of vanadium. The information given is complete and authoritative. Bulletin S-27.

METAL PROGRESS,
7016 Euclid Ave., Cleveland.

Please have sent to me the following literature as described in the March issue. (Please order by number.)

. . . .

. . . .

Name . . . .

Position . . . .

Firm . . . .

Address . . . .

TEST PRACTICE

(Continued from page 26) in all parts of the cabinet. Pieces under test should be suspended or supported in such a manner that the solution will not be retained in pockets (unless the position of the part in service is such as to cause retention in the same pockets) and left until the first appearance of corrosion of underlying metal. The solution should be changed frequently to avoid concentration by evaporation or contamination.

(3) *Thickness* of the coating may be measured under a microscope, by micrometer, or by strip tests.

(4) Coatings may also be tested for *porosity* by microscopic examination or by means of ferroxyl or similar papers.

(5) *Tri-chlor-acetic acid* test indicates porosity or insufficient nickel and tin plates over brass, bronze, or other copper alloys. A blue color appears upon immersing the part in a fresh solution of 100 grams tri-chlor-acetic acid, 700 c.c. water, and 400 c.c. ammonium hydroxide (sp.gr. 0.90). The time required for the blue color to appear is the measure of the quality of the plating from the standpoint of porosity and thinness.

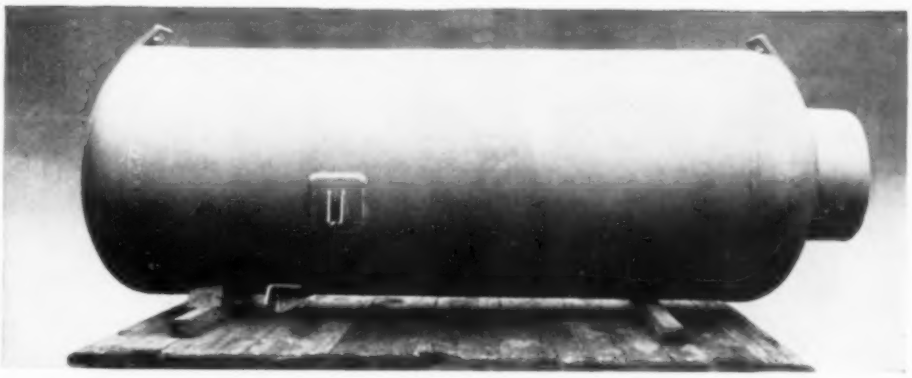
Distribution of Results — When tests on many pieces having the same composition and commercial treatment are plotted, the results are scattering but tend to conform in degree of frequency to what is known in mathematics as the "normal exponential distribution law." (This was explained by Dr. Hayes in METAL PROGRESS, Sept., 1931.) It is therefore impossible to specify too narrow a range on any measured property, without making allowance for some pieces having extreme values.

For example, if the Brinell hardness were determined of a shipment of bolts furnished under a 50-point range in the specification, 95% of the pieces might be found within the range; 5 out of every 100 might be too hard or too soft. If, however, a spread of only 40 points were allowed, only 85% might pass, and if only 30 points were allowed, only 70% might be found within the specified range.

The Service Was Hazardous...

Light Weight Was Essential...

One of the thirty pressure vessels, arc welded from Chrome-Vanadium Steel, [illegible]" shell, [illegible]" heads. The vessels measure 3' 5 1/2" I. D., by 8' 1 [illegible]" in shell length. They were tested at 500 lbs. water pressure and 100 lbs. air pressure, and operate at working pressure of 205 lbs.



So Chrome-Vanadium Steel Was The Material Selection

SAFETY of operation in the hazardous service was one essential. Minimum weight was the second requirement in the design and construction of thirty pressure vessels for operation at 205 lbs. working pressure.

Chrome-Vanadium Steel was selected as the material of construction for the thirty pressure vessels because its superior physical properties permitted design and manufacture to meet the stringent requirements of safety and light weight.

These thirty pressure vessels have been in service for more than a year and a half and are reported to "have proved entirely satisfactory in every respect".

Chrome-Vanadium Steels possess excellent mechanical properties at both room and moderately elevated temperatures. They are exceptionally uniform in both large and small masses, and adaptable to all fabricating operations. Hence, they have been widely used in forged pressure vessels and in both light and heavy welded units.

If you design, build or use pressure vessels for any service, you will be interested in the applications and service records of Chrome-Vanadium Steels in pressure vessel work. Our Metallurgists will gladly give you complete data. Write us today.

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VANCORAM

FERRO - ALLOYS

of vanadium, silicon-chromium and titanium; silico-manganese, tungsten and molybdenum, produced by the Vanadium Corporation of America, are used by steel makers in the production of high-quality steels.

Chrome-Vanadium Steels

For Forged and Welded Pressure Vessels

GRADED HARDENING

(Continued from page 30)

However, a fact should be emphasized, which agrees with what has been found in practice — that if the piece is held for long periods of time at temperatures above the third zone, that is to say, above the martensite point, it is not sufficiently hard. (Compare the results of quenching in lead at 350° C. for 3 min. and for 10 sec. The same time effect is noted for oil quenches at 250° C.)

This removes the advantage of Dr. Wever's proposed system of hardening, because this steel, held only a short time, does not reach a proper temperature equilibrium, and therefore internal stresses are not relieved in large pieces. Yet it is precisely with large pieces that the danger of cracks is greatest!

Hardening in oil emulsions or in hot, saturated sodium chloride solutions at temperatures up to 90° C. gives good results, and is easily done in practice. Table III also shows the limiting conditions under which a ⅝-in. disk can be quenched in order to attain glass hardness. Fractures for pieces hardened according to the first six lines in Table III are shown at the left of the halftone on page 30.

According to a letter from Dr. Schottky, Dr. Wever's propositions have been studied in the Krupp laboratory, and the range of austenite stability for alloy steels was confirmed. However, a region of austenite stability for straight carbon steel was not located. This agrees with the above-mentioned experience in other hardening departments.

It can be proved that graded hardening gives a uniform hardness throughout the piece, but, of course, the hardness of tools made of low alloy steel is often too low, for it is usually necessary to keep above file hardness, that is, above Rockwell C-62. However, it is to be anticipated that the most use of Dr. Wever's findings can be made by users of low alloy steels for machines and engineering purposes, for the desired hardness and strength for many applications can easily be secured by a graded quench and draw.